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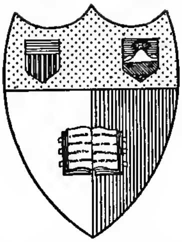

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MEMOIRS OF THE GEOLOGICAL SURVEY.

ENGLAND AND WALES.

EXPLANATION OF SHEET 269.

THE GEOLOGY
OF THE COUNTRY AROUND
WINDSOR AND CHERTSEY

BY

HENRY DEWEY, F.G.S.,

AND

C. E. N. BROMEHEAD, B.A., F.G.S.

PUBLISHED BY ORDER OF THE LORDS COMMISSIONERS OF HIS MAJESTY'S TREASURY.

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156. LEICESTER	8 3	1 6	3 0
187. HUNTINGDON	—	6 0	—
203. BEDFORD	—	9 9	—
228. HAVERFORDWEST	—	—	3 6
229. CARMARTHEN	1 6	1 6	2 0
230. AMMANFORD	1 6	1 6	2 6
231. MERTHYR TYDFIL	1 6	1 6	1 6
232. ABERGAVENNY	1 6	1 6	2 0
246. WEST GOWER	1 6	1 6	0 8
247. SWANSEA	1 6	1 6	2 6
248. PONTYPRIDD	1 6	1 6	1 6
249. NEWPORT (Mon.)	1 6	1 6	1 6
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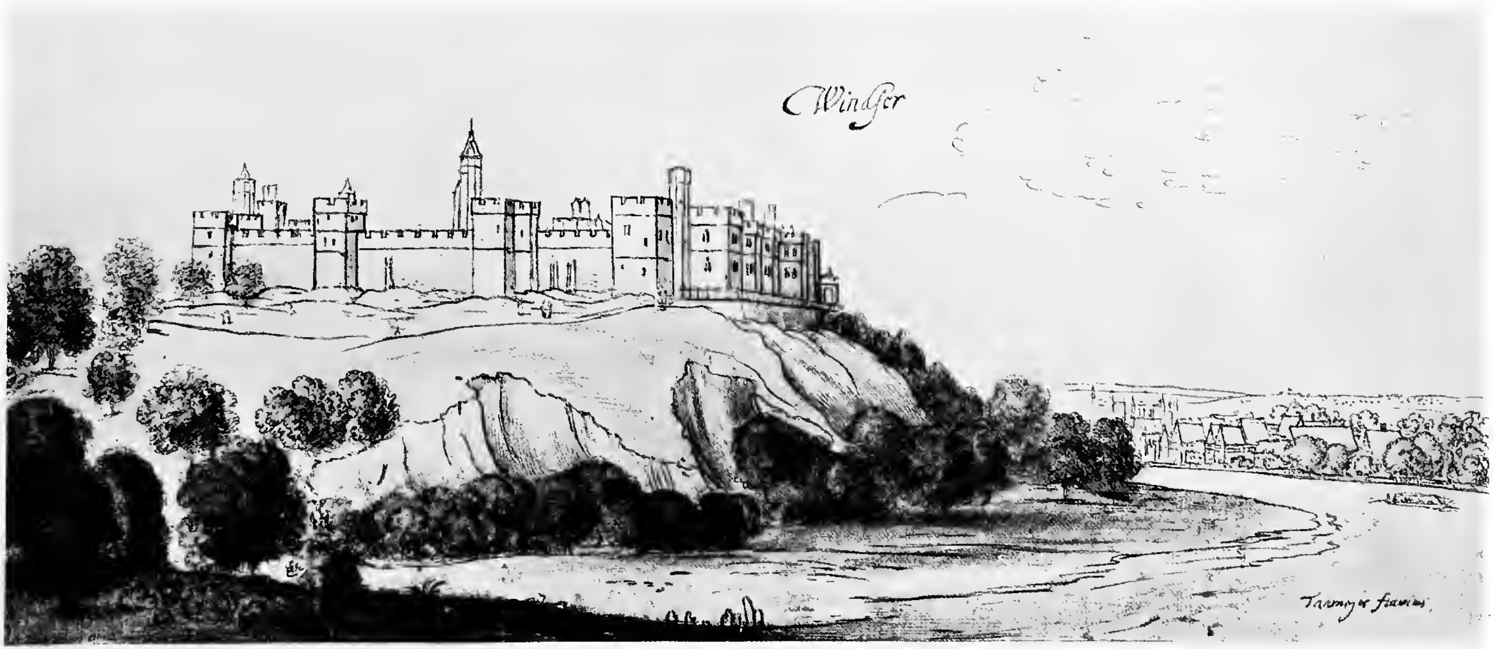

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ENGLAND AND WALES.

EXPLANATION OF SHEET 269.

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PREFACE.

The area described in the following pages was originally surveyed, as regards the Solid Geology, on the Old Series One-inch Map, Sheets 7 and 8, published in 1861 and 1862 respectively. The work was mainly that of Messrs. T. R. Polwhele and W. Whitaker. A new edition of Sheet 8 was published in 1868 and some corrections were made in Sheet 7 in 1865 and 1870.

Some years later, it having become apparent that the distribution of the Superficial Deposits deserved attention no less than that of the underlying 'Solid' strata, the ground was re-examined by Messrs. W. Whitaker, F. J. Bennett, J. H. Blake, C. E. Hawkins, and others. Drift Editions of Sheets 7 and 8, founded on this re-examination, were published in 1871 and 1887 respectively. In 1903 the Special One-inch Map of London was published. This was founded on a new survey on the six-inch scale, carried out by Messrs. J. A. Howe and T. I. Pocock. It includes a part of the area covered by Sheet 269.

In 1910 the field-work of the staff of the Geological Survey, so far as regards England and Wales, was concentrated on three districts, and among them on the populous region of London and the South-East. The six-inch survey of this District was commenced in the one-inch Sheets 269, 255 and 238, at the margin of the area previously surveyed on that scale, and was carried eastwards. Sheet 269 is the first map published in the District instituted in 1910.

The surveying has been carried out by Messrs. H. Dewey and C. N. Bromehead under the superintendence of Mr. C. Reid as District Geologist. On Mr. Reid's retirement at the close of the year 1912, the superintendence of the District passed into the hands of Mr. G. Barrow.

The area covered by this map includes regions typical of the soil and scenery of the Home Counties. Tracts of bare Chalk, the rich gravel-plains of the Thames Valley, the undulating land underlain by the London Clay, and the woods and heaths of the Tertiary uplands are characteristically represented. Of the Tertiary strata a greater thickness has been preserved from denudation than in other parts of the London Basin, for here the syncline to which the basin owes its existence attains its greatest depth. The axis crosses the southern part of the map with a general trend to the east-north-east.

The strata thus preserved extend up into the Barton Beds and have an aggregate thickness of upwards of 850 ft. The history of their investigation is contained in a copious literature, but among those who have attempted the difficult task of establishing the Eocene sequence, the name of Prestwich stands pre-eminent. Mention must be made also of the work of Messrs. W. H. Hudleston, H. W. Monckton and the Rev. A. Irving on the Bagshot Beds.

The superficial deposits have received much attention, not only from these geologists, but from Messrs. Ll. Treacher, H. Bury, and others. An increasing interest in them, and especially in the valley-deposits, is roused by the more systematic collecting and examination of flint-implements which has been in progress of late years. On the map now published three terraces are distinguished in the Thames Valley, and there is some reason for thinking that the implements yielded by them may be assignable to recognised Continental types.

The question of water-supply from local underground sources is dealt with in this Memoir, but for a consideration of the resources of the London Basin as a whole reference should be made to the Memoir on London Wells, and to that of the Water Supply of Surrey.

A. STRAHAN,
Director.

Geological Survey Office,
London, S.W.,
21*st September*, 1914.

LIST OF SIX-INCH MAPS.

The following is a list of the 6-in. Geological Maps included in the area, with the name of the surveying officer, and the date of survey in brackets. Manuscript coloured copies of these maps are deposited for public reference in the Library of the Geological Survey and Museum of Practical Geology:—

BERKSHIRE (surveyed in 1910).

30 NE., SE. (part), C. N. Bromehead.
31 NW., SW., SE., C. N. Bromehead.
32 NW., NE., SW., SE., C. N. Bromehead.
38 NE. (part), C. N. Bromehead; SE. (part), H. Dewey.
39 NW., NE., C. N. Bromehead; SW., SE., H. Dewey.
40 NW., NE., C. N. Bromehead; SW., H. Dewey.
46 NE., SE. (parts), H. Dewey.
47 NW., NE., SW., H. Dewey.
48 NW., H. Dewey.
49 NE. (part), H. Dewey.
50 NW. (part), H. Dewey.

BUCKINGHAMSHIRE.

55 NE., SE., C. N. Bromehead (1910).
56 NW., C. N. Bromehead (1910); NE., J. A. Howe (1902) and C. N. Bromehead (1911).
56 SW., C. N. Bromehead (1910); SE., T. I. Pocock (1902) and C. N. Bromehead (1911).
57 NW., SW., J. A. Howe (1902).
58 NW., NE., C. N. Bromehead (1911).

MIDDLESEX.

14 SE., J. A. Howe (1902).
15 SW., J. A. Howe (1902).
19 NW., NE., J. A. Howe and T. I. Pocock (1902); SW., SE., T. I. Pocock (1902).
20 NW., J. A. Howe and T. I. Pocock (1902); SW., T. I. Pocock (1902).
24 NW., NE., SE., T. I. Pocock (1902).
25 NW., SW., T. I. Pocock (1902).

SURREY.

4 NE., C. N. Bromehead (1911); SE., H. Dewey (1910) and C. N. Bromehead (1911).
5 NW., C. N. Bromehead (1911); SW., T. I. Pocock (1902) and C. N. Bromehead (1911); SE., T. I. Pocock (1902).
9 SE., H. Dewey (1910).
10 NW., NE., SW., SE., H. Dewey (1910 and 1911).
11 NW., NE., T. I. Pocock (1902) and C. N. Bromehead (1911); SW., S.E., C. N. Bromehead (1911).
12 NW., T. I. Pocock (1902); SW., T. I. Pocock (1902), and H. Dewey and C. N. Bromehead (1911).
15 NE. (part), H. Dewey (1910).
16 NW. (part), H. Dewey (1910); NE. (part), H. Dewey (1911).
17 NW., NE., C. N. Bromehead (1911).
18 NW., H. Dewey and C. N. Bromehead (1911).

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THE GEOLOGY

OF THE COUNTRY AROUND

WINDSOR AND CHERTSEY.

CHAPTER I.

INTRODUCTION.

The area described in the present Memoir includes portions of the counties of Bucks and Middlesex, to the north of the Thames, and of Berkshire, Surrey and a small part of Hampshire, to the south of the river. Its boundaries are shown in the sketch-map (Fig. 1), in which also the broader outlines of the geological structure are indicated. The entire area is drained by the Thames and its tributaries. Of these the most important, on the north side, is the Colne, and, on the south side, the Wey, the Mole and the Blackwater.

The clay country, stretching westward from Windsor Great Park, is drained by small streams, most of which are nameless. The largest of these rises near Ascot and flows westward to Binfield where it turns to the north. Its natural course was west again at Beenhams Heath, and it eventually joined the Loddon; early in last century, however, a cut was made to drain Ruscombe Lake, which lies a little to the west of the area, and the water now flows in a north-easterly direction to join the Thames at Bray.

Two somewhat larger streams rise within the higher sandy area, which stretches in a north-easterly direction from Crowthorne to Virginia Water. The more northerly of these, the Bourne, rises near Virginia Water and flows for some distance in a south-east direction; then turning north it reaches the Thames valley deposits near Thorpe, and flows across them in a south-easterly direction to find an outlet close to Weybridge. This peculiar course is due to a diversion of the stream described on p. 88.

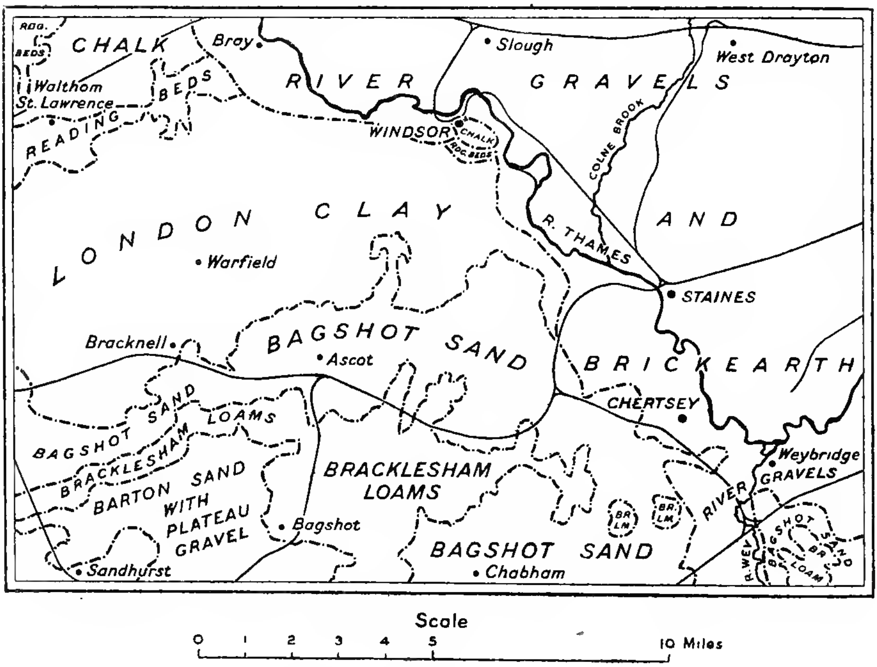
Virginia Water has been formed by damming up the three head branches of the Bourne; the dam is sufficiently high to retain the water for some distance up each branch valley and to this circumstance the picturesque form of the lake is due.

The more southerly and larger stream rises in Bagshot Park and flows nearly due east for some ten miles; passing through Chobham and joining the Wey valley near New Haw. Thence it flows across the gravels of the Wey and joins that river about a mile above its confluence with the Thames. This stream also is, in the lower part of its course, called the Bourne, but above Chobham, the Hale Bourne and near its source, the Windle Brook.

Physical Features.

Physiographically the area is divided into three main types. The first lies to the north and east of the Thames and consists of a wide expanse of flat and comparatively low-lying ground, formed for the most part of river deposits (*see* Fig. 1). The second occupies the northern part of the area on the other side of the Thames and stretches westward from Windsor to the edge of the map; it is a rich gently undulating country underlain by the Lower London Tertiaries. In marked contrast to this is the third type, forming nearly the whole of the southern part of the area; it includes the highest ground, which rises near Crowthorne to more than 400 feet above the sea and forms a long narrow plateau. It is composed mainly of the sands of the Bagshot Series and consists of alternations of open heaths and extensive pine-forests.

Fig. 1. Sketch Map of the Geology of the Area in Sheet 269.



Chalk.—Of the chalk little need be said; owing to the wash from the neighbouring Tertiary strata the soil is comparatively thick, and almost the whole area is under cultivation; the chalk does not form the highest ground, being dominated to the south by the Tertiary escarpment, and on the north by Bowsey and Ashley Hills, which consist of Reading Beds and London Clay capped by ancient gravels, the flanks only being within the area here dealt with.

At Windsor the chalk rises to form the prominent feature known as the Castle Hill. This inlier probably owes its existence to the intersection of two anticlines: but the dome has been cut into by the Thames, and the steep northern face, though now clothed with shrubberies, has also been affected by quarrying, as seen in the frontispiece. This drawing gives the aspect of the hill in the time of Charles II., and is reproduced from an original by Hollar in the Royal Library at the Castle by special permission of H.M. the King.

Reading Beds and London Clay.—The clay tract forms gently undulating ground mostly laid down to grass but relieved by fine woods. Windsor Great Park and much of the Forest are situated upon it. The latter had once a much larger extent than to-day, and the picturesque half-timbered houses of the crofters catch the eye in many of the hamlets. Owing to the impermeability of the clay the rainfall runs off quickly.

Bagshot Beds.—The vegetation growing upon these beds offers a marked contrast with the oaks and elms of the clay-lands further north, and consists almost entirely either of dense pine woods or wide open heaths on the hills and peaty swamps in the valleys. Where the loams and clays of the Bracklesham series come to the surface the soil is less barren, but scarcely repays cultivation of crops. On account of the absence of lime from it, however, and its peaty nature, it has been chosen for the cultivation of rhododendrons and allied plants, especially in the neighbourhood of Bagshot and Windlesham. The valley slopes clothed with deciduous trees, especially sweet chestnut, form picturesque scenery contrasted against the foil of dark coniferous woods behind them.

St. George's Hill occupies a commanding position between the valleys of the Wey and Mole; it has been preserved from denudation by a capping of Plateau Gravel. The soil is essentially sandy, the outcrop of the Bracklesham clays being for the most part overspread by Drift Sand. At the time of the survey it was clothed with pine woods diversified with groves of silver birch and a few beeches and oaks; many clumps of rhododendron have been planted, and bracken grew luxuriantly. Since then the estate has been 'developed,' many new roads being cut, large houses built, and a golf-links constructed.

While still partly retaining its wild, uncultivated character, much of the area has assumed a suburban aspect, comparatively small villages having grown into fair-sized towns. The change is perhaps most marked along the banks of the Thames.

The most important towns are Windsor with a population in 1911 of 12,700, and Slough with nearly 5,000. The more distinctly suburban towns are Staines, Egham, Chertsey, Walton, Weybridge, and Byfleet.

H. D.; C. N. B.

TABLE OF STRATA.

The geological formations indicated by colours on the map are as follows:—

RECENT	Alluvium.		
	Peat.		
PLEISTOCENE	Brickearth		Sandy Clay.
	River Terraces:—		
	Flood Plain Gravel		Gravel and Sand.
	Taplow ,,		,, ,,
	Boyn Hill ,,		,, ,,
	Plateau Gravel		,, ,,
EOCENE	Barton Beds		Sands.
	Bracklesham Beds		Clays, pebbles and Sands.
	Bagshot Beds		Sands with Clay Seams.
	London Clay		Stiff Clay.
	Reading Beds		Clays and Sands.
CRETACEOUS	Upper Chalk.		
	Middle Chalk		Not seen at the surface.
	Lower Chalk		
	Upper Greensand	Selbornian	
	Gault		
	Lower Greensand		

Of the formations enumerated above, all below the Upper Chalk have been met with in borings only and do not reach the surface in this area.

CHAPTER II.

CRETACEOUS.

Within this area three borings for water have penetrated the Chalk and the whole of the Selbornian, and have entered the Lower Greensand. The following table gives a summary of the results:—

	Ottershaw, O.D. 142.5	*Winkfield,* O.D. 218.	*Slough,* O.D. 100.
	Ft.	Ft.	Ft.
Tertiary Beds	649	214	79
Chalk	646	725	757
Upper Greensand	40	31	19
Gault	238	264	166
Lower Greensand	to 12	to 9	to 13
TOTAL	1,585	1,243	1,034

LOWER GREENSAND.

(PROVED IN BORINGS ONLY.)

The figures given above show that the top of the Lower Greensand rises steadily to the north, lying at 1,431 feet below sea-level at Ottershaw, at 1,016 at Winkfield and 921 at Slough. It is probable that Ottershaw is near the axis of the great syncline that passes under London, the other two localities being situated on the northern limb of the fold.

Messrs. Whitaker and Jukes-Browne[1] describe the Lower Greensand of Winkfield as a fine, sharp, light-brown sand. At Ottershaw it has decomposed to a coarse, brown, quartz-sand; the grains, which were brought to the surface by the overflowing water, are well rounded, but do not show the glossy, open metallic surface met with elsewhere. This incoherence of the rock points to its exposure and decomposition prior to the deposition of the Gault.

SELBORNIAN: UPPER GREENSAND AND GAULT.

(PROVED IN BORINGS ONLY.)

It has long been known that the distinction between Upper Greensand and Gault is of little stratigraphical value. The two lithological types shade into one another, and owing to slight changes in the conditions of deposition, the sandy beds of one locality may be contemporaneous with clayey beds in other parts. In accordance with the suggestion of Mr. A. J. Jukes-Browne,[2] the two divisions are therefore grouped together under the title Selbornian. The following table shows the thickness in feet of the strata proved in the three borings situated within the Windsor Map and in certain others lying not far to the east:—

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[1] Whitaker, W. and A. J. Jukes-Browne. *Quart. Journ. Geol. Soc.*, vol. l, 1894, pp. 496-501.

[2] 'Cretaceous Rocks of Britain.' *Mem. Geol. Surv.*, vol. 1, 1900, p. 1.

	Slough.	Winkfield.	Ottershaw.	Southall.	Park Royal.	Chiswick.	Richmond.	Streatham.
Upper Greensand ...	19	31	40	16	14	23	16	29
Gault	166	264	238	122	155	177	201	188
Total thickness ...	185	295	278	138	169	200	217	217
Depth of base below O. D....	921	1,016	1,431	1,035	1,048	1,090	1,141	971½

The steady dip southward from Slough to Ottershaw and from Southall to Richmond is due to the great London syncline which in this district has a slight pitch to the west. It is also noticeable that the thicknesses of the easterly series are less than those at corresponding latitudes to the west; it is probable that this difference is due to the non-deposition on the east of beds contemporaneous with the lowest beds found on the west.

The lithological characters of the Selbornian are of considerable interest. The division into Upper Greensand and Gault is, as mentioned above, purely lithological. Each of these types can be further subdivided; the topmost bed is usually a sandy marl containing much glauconite, whence arises the term Greensand; below this come hard silty hearthstones, which are also classified as Upper Greensand. These beds pass gradually down into the marls of the Upper Gault, which in turn show a transition to unctuous blue-grey or black clays of the Lower Gault. This last division contains one or more glauconitic layers, which appear to be constant over a considerable area, and has frequently a layer of phosphatic nodules at its base. The following table gives the thicknesses of these divisions at Winkfield,[1] and Ottershaw, to which those proved at Richmond[2] are added for comparison:—

	Winkfield.	Ottershaw.	Richmond.
	Ft.	Ft.	Ft.
Green Sand Marls	10	25	—
Hearthstone and Firestone	21	15	16
Upper Gault Marls	210	238	150
Lower Gault Clays	50		50
Sandy Clay with Nodule Bed ...	4	—	1½

At Winkfield a specimen of the Upper Greensand Marl is described by Messrs. Whitaker and Jukes-Browne[3] as a 'hard grey marl full of grains of quartz and glauconite.' The Hearthstone is a 'calcareous malmstone, having a matrix of granular calcite, with many angular bits of calcitic shell, many sponge-spicules and minute scattered grains of quartz and of glauconite. This slide also shows a great number of black specks (pyrites?) which fill chambers of very small foraminifera (*Textularia* and others).' (*ibid.*) The proportion of calcareous matter decreased downwards giving a passage to the Upper Gault Marls which were at first 'hard, dry, friable, light-grey clay' becoming darker and softer below; these yielded specimens of *Hoplites splendens* (J. Sow.) and *Inoceramus sulcatus* Park., and contained a layer of phosphatic nodules 9 ft. above the base. The succeeding Lower Gault was of the usual type with a basement bed of brown and dark greenish sandy clay, and finally a layer of phosphatic nodules.

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[1] 'Cretaceous Rocks of Britain.' *Mem. Geol. Surv.*, vol. i, 1900, p. 368.
[2] *Ibid.*, p. 369.
[3] *Quart. Journ. Geol. Soc.*, vol. l, 1894, p. 498.

At Ottershaw the Upper Greensand Marls were of a dark brownish-grey colour with very numerous small grains of glauconite scattered irregularly through the mass. The hearthstones were fine-grained sandstones, highly calcareous in the upper part, with minute flakes of mica. From these beds the passage to the Upper Gault was gradual. A nodular band with highly glauconitic patches occurred between the depths of 1,365 and 1,369 ft., 30 ft. below the line adopted as the division between the Hearthstones and the Gault: a second glauconitic layer was met with at 1,380 ft. separated from the upper one by 11 ft. of grey marls without visible glauconite. The specimens collected did not show any recognisable basement bed.

From Slough we have no details, except that Mr. Barrow obtained a sample of typical Upper Greensand Marl from a depth of 850 ft.

As the basement bed was proved to be present both at Richmond and still further east at Meux's in Tottenham Court Road, it may be present both at Ottershaw and Slough. The material of which it is composed is likely to disintegrate easily and give no core.

In dealing with the underground structure of the south-east of England Dr. Strahan[1] has shown that the base of the Gault in the present area descends below the contour of—1,000 ft. O.D., indicating that the region of its greatest depression in the London Basin lies in the southern part of the Windsor sheet.

C. N. B.

CHALK.

GENERAL ACCOUNT.

The Chalk has an outcrop at the surface covering about six square miles in the north-west corner of the map, in addition to which there is a small inlier at Windsor. The underground extension beneath the Tertiary formations has been proved by borings in almost every part of the area; some of these have afforded much information of geological interest, while others, to which reference will be found in the chapter on Water Supply, give little beyond the depth at which the Chalk occurs.

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[1] Presidential Address Geol. Soc. *Quart. Journ. Geol. Soc.*, vol. lxix, 1913, pp. lxx-xci.

The outcrop exposes only a small part of the Upper Chalk, but the three deep borings at Winkfield, Ottershaw, and Slough, afford information about the underlying divisions, while that at Slough appears to have penetrated zones of the Upper Chalk higher than any exposed elsewhere in the district. The total thickness of the chalk as proved in the borings referred to has been already given (p. 5.)

LOWER AND MIDDLE CHALK.

In their account of the Winkfield boring Messrs. Whitaker and Jukes-Browne[1] give the following section and description of the Lower and Middle Chalk, beginning at a depth of 543 ft. below the surface.

			Ft.	in.
[? CHALK ROCK] ...		Hard grey chalk and flints	8	0
MIDDLE CHALK 169 ft.		Hard white chalk	13	6
		Grey sticky chalk and flints	2	6
		,, ,, a flint at 578 ft.	15	0
		(Another account says hard white chalk, 20ft.)		
		White sticky chalk	8	0
		White chalk	27	0
		Grey sticky chalk	6	0
		Hard white chalk	25	0
		Hard sticky white chalk...	2	0
		Hard chalk	29	6
		Hard white chalk	14	6
		Grey gritty chalk	4	0
		Chalk marl	4	0
		Hard white chalk	4	0
		Very hard white chalk [? Melbourn Rock.] ...	14	0
LOWER CHALK, 219 ft.		White and green chalk [? Belemnitella Marl]...	6	0
		White chalk	27	0
		Hard white chalk	44	0
		Free-cutting white chalk	12	0
		Hard white chalk	15	0
		Very hard white chalk	7	9
		Very hard grey chalk	17	1
		Hard dark grey chalk [? Totternhoe Stone] ...	18	2
	[Chalk Marl, 72 ft.]	Blue clayey chalk. Specimen with minute flakes of mica and some black specks	1	0
		Dark-brown clayey chalk	21	0
		Grey chalk, with hard bands from 1 to 13 inches thick, specimen from 927 ft. : (like the hard beds of the chalk marl with "spheres," Hill). Specimen from the base : dark grey marl, with quartz-grains, mica-flakes, and black particles [? glauconite] ; small bits of glauconitic marl	50	0

* * * * * *

‘There is some doubt as to the position of the *Chalk Rock*, and it may be that it is the bed below that suggested which ought to be so classed. Of course, therefore, the division between the *Upper* and the *Middle Chalk* is somewhat doubtful.

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[1] *Quart. Journ. Geol. Soc.*, vol. l, 1894, pp. 496-501.

'The *Lower Chalk* is rather thick, and the whole formation of the *Chalk* is about 80 ft. thicker than under London and 55 ft. thicker than at Richmond. So clayey are some of the specimens from the *Chalk Marl* that we were at first inclined to think, as also was Mr. W. Hill, that the Gault might have been reached, and therefore that the Upper Greensand was absent—a view that was of course negatived when the last-named formation was found to occur still lower. A specimen from 927 ft. [12 ft. above the Upper Greensand] was submitted to Mr. W. Brierly (of Southampton), who reports that it is composed of 62·1 per cent. of calcium carbonate, with a small quantity of iron, etc., and 37·9 per cent. of clayey matter—a composition not varying much from that of some highly calcareous Gault.'

The boring at Ottershaw Park was carried down through the whole of the Chalk, but the record was confused by difficulties that were encountered after 40 ft. of the Upper Chalk had been penetrated. Owing to these difficulties no reliable details were obtainable for the 211 ft. of beds between the depths of 689 and 900 ft., and as this gap covers the position of the Chalk-rock, the division between the Upper and Middle Chalk could not be fixed.

A brief description of the section to a depth of 1,556 ft. was published by Mr. C. Reid[1] in 1911 from the information then available, and this account was reprinted with further particulars and additions in a later publication of the Survey.[2] Many additional specimens from the boring were procured by the Survey fossil-collector, Mr. J. M. Muir, and a study of the whole of the available material has led to some modification of the previous reading of the section. The base of the Lower Chalk appears to have been reached at 1,295 ft. below the surface, instead of at 1,215 ft. as previously supposed, the beds at some distance above the base having, as at Winkfield, an aspect that is usually seen only in the lowest beds of the Division. The data relating to the Chalk in this boring are summarized in the following section:—

			Ft.	Ft.
Tertiary Strata			649	649
Chalk, 646 ft.	Middle and Upper Chalk exceeding 401 ft., not exceeding 468 ft.	Soft white chalk, black flints with thin rind	40	689
		No details	211	900
		Hard white chalk with *Terebratula* and *Rhynchonella* [Middle Chalk]	27	927
		Cream-coloured chalk, very hard and splintery	9	936
		Yellow and grey marly chalk	10	946
		Hard white chalk with *Inoceramus*	104	1,050
	Lower Chalk exceeding 178 ft., not exceeding 245 ft.	No specimens	67	1,117
		Buff chalk with greenish tinge [Lower Chalk]	6	1,123
		White chalk	30	1,153
		Greyish chalk	107	1,260
		Grey marly chalk	35	1,295
		Upper Greensand		

At 1,184 ft. an ammonite (*? Mantelliceras*) was found, and another, *Calycoceras naviculare* (Mant.), at 1,290 ft.

It will be observed that the boundaries between Upper and Middle and between Middle and Lower Chalk occur where there are gaps in the set of specimens obtained and the thicknesses of the divisions are therefore doubtful.

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[1] 'Summary of Progress for 1910.' *Mem. Geol. Surv.*, 1911, pp. 25-26.

[2] 'The Water Supply of Surrey.' *Mem. Geol. Surv.*, 1912, p. 134.

At Slough no division of the Chalk can be made with any confidence. The section, according to the well-sinkers, Messrs. Isler & Co., was as follows:—

	Ft.	ins.
Chalk and Flints	463	3
Hard Chalk	154	9
Grey Chalk	96	0
Green Sandy Chalk	6	0
Grey Chalk	37	6
Grey Sandy Chalk [Upper Greensand]	19	4

The total thickness of chalk is probably 757½ ft. This is a maximum for the district, other known amounts being Winkfield 725, Southall 702, Richmond 670, Ottershaw 646, Chiswick 632. The increase is probably due to the incoming of higher zones.

UPPER CHALK.

The Upper Chalk, where exposed at the surface, is a soft, white and fairly homogeneous rock, containing flints which occur mostly as irregular shaped nodules of variable size. These are often arranged in rows, but they are also irregularly distributed through the rock. Flint also occurs in a tabular form, that is, in a continuous layer of variable thickness, averaging about half an inch. It is occasionally developed at a high angle to the bedding, probably accompanying the formation of joints or faults. Of the palaeontological zones into which the Upper Chalk has been subdivided, only that of *Micraster coranguinum* has been definitely recognised within the map, though zones both above and below this horizon are known to occur to the north and west. Fossils are, however, rare, and the evidence scanty, while the flints are of little value as zonal indicators. Tabular flint is, however, common in the upper and scarce in the lower part of the Coranguinum Zone. The fossils found and the character of the flints at each pit are noted in the following pages.

LOCAL DETAILS.

Beginning with the western area north of the railway, there is a small pit in the grounds of Linden House, near Knowl Hill, 200 yds. west of the eighth milestone from Reading on the Bath road. This shows about 5 ft. of rather rubbly chalk, which probably belongs to the lowest part of the Coranguinum Zone, but the only fossil found was *Echinocorys scutatus* Leske. Similar chalk is exposed in another pit at Warren Row about a mile to the north and is taken by Messrs. Treacher and White[1] to be 'well down in the Micraster Coranguinum Zone.'

At both pits the Chalk is overlain by the Reading Beds. The authors referred to consider that at Ruscombe Lake, just west of this area, the chalk belongs to the highest part of the same zone, immediately beneath the Uintacrinus Band. Chalk is still exposed in a small pit west of Weycock Hill, at the point where the parish boundary is cut by the edge of the map, and as this exposure is less than one mile from that at Ruscombe it is almost certainly at the same horizon. This view is strengthened by the occurrence at both places of layers of thin tabular flint, while large nodules are absent.

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[1] 'The Higher Zones of the Upper Chalk of the Western Part of the London Basin.' *Proc. Geol. Assoc.*, vol. xix, 1906, p. 393.

North of Knowl Hill there are two old chalk pits beside the main road, one opposite to the church, the other in the angle between this road and the lane from Cold Harbour; the latter now shows about 10 ft. of thin-bedded fairly hard chalk with two layers of flint nodules of large size and irregular shape, which have a thick white crust and are greyish-black inside. The horizon is probably rather low down in the Coranguinum Zone. A pit at Chalkpit Farm, by the turning to Great Marlow, shows 20 ft. of chalk with six layers of flints similar to the above; a fragmentary micraster was found not more than 10 ft. down; though too imperfect for specific identification, it has been assigned by Dr. Rowe to the Coranguinum Zone. The Chalk is here capped by the Reading Beds. Further to the east, at Wooley Green, is a large pit showing 30 ft. of chalk; in the lower part the beds are thick, but towards the top much thinner. Near the bottom there are two layers of tabular flint; but at 8 ft. and at 20 ft. above the base large flint nodules, black inside and covered with a thin white rind, occur in well-marked bands. *Micraster coranguinum* (Leske.) and *Pecten* (*Chlamys*) *cretosus* Defr. were found here. The occurrence of numerous other fossils in the three pits described above has been recorded by Mr. Jukes-Browne.[1]

Half a mile east of Wooley Green and south of Tittle Row there is a large chalk pit, still worked to a small extent. About 25 ft. of rather soft chalk is exposed, with flint at three horizons; of these the lowest, consisting of tabular flint, forms the floor of the quarry, while at 6 ft. and 14 ft. above there are horizontal bands of large irregular nodules. *Bourgueticrinus ellipticus* (Mill.), many fragments of *Inoceramus* and a fish coprolite were found here.

At Nordon Farm, east of Tittle Row, there is an exposure of some 12 ft. of chalk, apparently on the same horizon, which yielded *Ostrea normaniana* d'Orb., *Inoceramus*, and some fish-scales.

Along the railway there are some cuttings in chalk, all now overgrown.

South of Chambers's (or Shottesbrook) Farm, near the northern end of Shottesbrook Park, there are two pits, one of which is occasionally worked. The chalk, of which about 12 ft. is exposed, is much broken by joints and bedding planes, and at the top somewhat piped. The flints are large irregular nodules, solid and black within, having a moderately thick white crust; they form a horizontal course near the base, but above are scattered irregularly. Some of the joints are filled with thin tabular flint, which in one case was in continuity with a large nodule. Fossils are comparatively abundant; but usually shattered and difficult to extract. *Inoceramus* fragments are very plentiful, and fish scales by no means rare. We also obtained *Bourgueticrinus ellipticus* (Mill.), *Conulus* sp., *Echinocorys scutatus* Leske., and several fragmentary micrasters; of these one is identified by Dr. Rowe as *M. praecursor* Rowe; two others were found within a few inches vertically, but of one he writes, 'It indicates a position in the zone of *M. cortestudinarium*,' of the other, 'it probably belongs to the zone of *M. coranguinum*.' The chalk here may not be above the lower part of the Coranguinum Zone, but the palaeontological evidence is scanty.

Round White Waltham there are several old pits, but they are mostly grassed over.

Between Cox Green and Shoppenhanger's Farm a small pit on the north side of the lane exposes about 15 ft. of chalk with a few irregular flints; a marginal plate of *Pentagonaster quinqueloba* (Goldf.), part of a test of *Cidaris sceptrifera* Mant., and an oyster (not identifiable) were found here.

North of Staverton Lodge the Chalk disappears beneath the Thames gravels; the base-line of the Tertiary strata probably runs nearly due east as far as Burnham Abbey, where it turns northwards and enters the map to the north.

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[1] 'Geology of London.' *Mem. Geol. Surv.*, vol. i, 1889, pp. 76 and 79.

THE WINDSOR INLIER.

Windsor Castle is built upon a hill of Upper Chalk. On the Old Series Geological Survey Map, Sheet 7, this mass is shown as the extremity of a long tongue of chalk extending beneath the river gravels from the main outcrop about Maidenhead and Taplow. In 1864, Mr. Whitaker suggested that the outcrop of the Chalk at Windsor might be an inlier,[1] but it was not till 1887 that he obtained evidence confirmatory of his view. In this year two borings[2] were put down between Dorney and Boveney which proved the presence in one case of 20 ft. and in the other of 30 ft. of London clay under the river gravel. One of these was situated on the supposed outcrop of the Chalk beneath the river deposits, the other on that of the Reading Beds. They thus showed that the former idea of the structure of the ground was untenable and Mr. Whitaker's suggestion correct. The alteration was first officially made in the 4 mile to the inch map published by the Geological Survey in 1892.

Further light is thrown on the extent of this inlier by an earlier boring made at the side of the Datchet Road in 1882, and described by Mr. Logan Lobley;[3] the site is engraved on the map. There 20 ft. of London Clay was proved, and unless the Reading Beds are faulted out, as Mr. Lobley supposed, this series must crop out beneath the gravel in the space between the boring and the Chalk of the Castle Hill, as indicated on the map.

The northern limit of the inlier can be approximately fixed at one point. On Tangier Island a well proved the presence of a bed of sand, that appears to be the Bottom Bed (see below, p. 18) beneath about 20 ft. of river deposits; but only 200 yds. further south, at Romney Weir, bare chalk was seen covered by only 5 ft. of these deposits; the junction of the Chalk with the Reading Beds must therefore lie between these two points.

In Windsor itself there are borings situated near the junction of the Reading Beds with the London Clay, but they only inferentially give a clue to the position of the base of the Reading Beds beneath the river gravels; but where this horizon emerges from beneath the river deposits, along the south side of the hill, its position is fairly clear. Near the north end of Sheet Street, Lundy[4] records 14 ft. of Reading Beds, but at the time of the recent survey, an opening in the Royal Mews, close by, showed only a little made-ground above bare chalk. Through the Home Park the ground is covered by grass and the position of the junction is less certain; the 'Fairy Pit,' near Herne's Oak, was apparently made in bare chalk, but at the point where the Castle sewer crosses the path from the Kennels to the Home Farm, 6 to 8 ft. of clay was found above the Chalk.

The position of the junction of the Reading Beds with the Chalk can be traced sufficiently well to show that the Chalk of Windsor Castle occurs as an inlier of oval form about 1½ miles long. The outcrop seems to occur on the crest of a dome; though the dip of the beds can nowhere be measured at present, an inclination of 10 degrees would be sufficient to account for the structure shown on the map (see Fig. 2).

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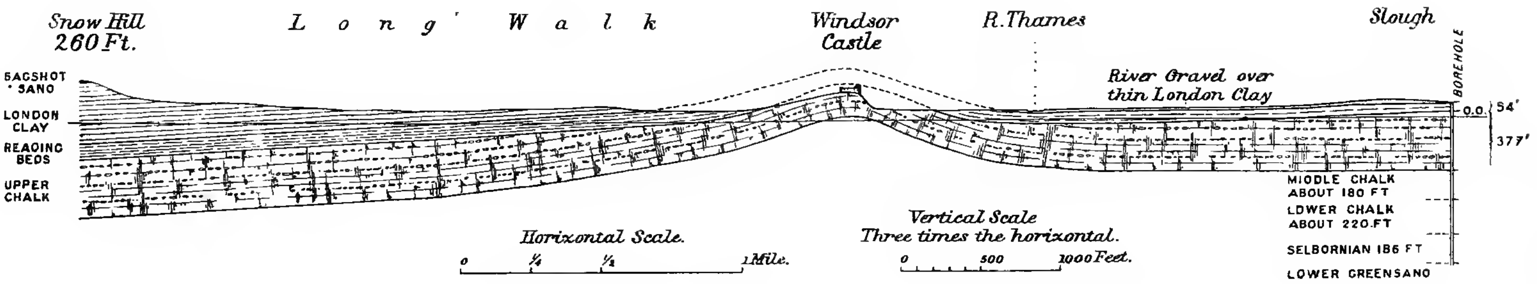
[1] 'Geology of Parts of Middlesex, etc.' *Mem. Geol. Surv.*, 1864, pp. 8, 11, etc.

[2] 'Geology of London.' *Mem. Geol. Surv.*, vol. ii, 1889, pp. 8 and 9.

[3] 'On a New Section in the Thames Valley.' *Proc. Geol. Soc.*, vol. vii, 1882, pp. 391-395.

[4] *Proc. Windsor and Eton Sci. Soc.* for 1886. Windsor, 1887, p. 15.

FIG. 2. HORIZONTAL SECTION THROUGH WINDSOR.



The structure of the inlier is shown in the accompanying diagrammatic section, Fig. 2. In the centre of the section is the chalk dome of the Castle Hill, partly cut away by the Thames, which now flows some distance to the north. On the right is the gentle slope of the Thames gravels: these are underlain by a thin cover of London Clay, which may here and there be cut through so that the gravels rest locally on the Reading Beds. The structure at the surface is due to a post-Eocene anticline, while the variation in the thickness of the Chalk is caused by pre-Tertiary flexures cut across by the basal plain of the Eocene Beds. The denudation of the anticline at Windsor leaves a relatively small amount of Chalk present there; while the greater thickness at Slough and Snow Hill occurs in synclinal troughs on either side.

The northern face of the Castle Hill is an ancient river-cliff of the Thames, in which, however, the chalk has been quarried to a considerable extent, as shown in the old picture reproduced as the frontispiece to this Memoir. The quarry faces are now sloped and bare chalk is no longer visible. The character of the flints suggests that the chalk belongs to the upper two-thirds of the Coranguinum Zone. At the time of the recent survey a small excavation was made near Adelaide Lodge; it yielded no fossils, but large irregular shaped flints were met with.

The thickness of the Upper Chalk has been determined at two localities within the map, Winkfield (p. 103) and Egham, at both of which the overlying Tertiary Strata are present. At the former the thickness of Upper Chalk, including 8 ft. of Chalk Rock at the base, was 337 ft. At Egham a boring was put down for the Staines Water Works and penetrated 346 ft. into chalk; specimens of hard grey chalk from the bottom were examined microscopically by Mr. W. Hill, who says they are 'undoubtedly Chalk Rock.'[1]

If the constancy in thickness of the various zones of the Chalk, as exposed in the country to the north and west, can be relied upon, the thicknesses given in these borings would suggest that at Winkfield the Tertiary Strata rest upon chalk belonging to the Marsupites Zone, at Egham possibly on that of *Actinocamax quadratus*.

PRE-TERTIARY EARTH-MOVEMENTS.

Before the Tertiary strata were laid down the Chalk was thrown into a series of gentle folds, across which a plane of denudation was cut. Sections which expose the junction of the two formations do not reveal any obvious discordance, but the existence of an unconformity is proved by the fact that the basal Tertiary beds do not rest consistently on any one zone of the chalk. The zone, which immediately underlies the Reading Beds at various localities within the map, has been noted above. A comparison of these with a somewhat wider area shows that there is no regular overstep of successive zones in any one direction, but rather that a plane has been cut across a series of gentle folds, whose axes run about E. 15° S. A synclinal axis seems to run near the northern margin of the map; thus at Taplow, a little to the north, there is nearly the whole thickness of the marsupite chalk present,[2] indicating a probable total thickness of about 325 ft. for the Upper Chalk. At Slough the chalk as a whole attains a maximum thickness for the district, 757 ft.; and at Southall, just beyond the eastern margin of the map, it is 700 ft. thick.

The thickness of Upper Chalk as revealed by borings at Streatham, Tottenham Court Road, and Kentish Town may indicate that the Tertiary strata there rest upon the upper part of the coranguinum zone, while at Winkfield and Richmond that of marsupites is probably present. The variations may be accounted for by postulating an anticlinal axis running through Knowl Hill and Windsor and on to Streatham, succeeded to the south by a syncline passing through Winkfield and Egham.

That there was some folding of the Chalk in pre-Tertiary times is certain, but the evidence for the system of approximately east-and-west axes indicated above is as yet too slight to allow of a definite map being made; but one other point of interest may be mentioned. Fig. 2 is a horizontal section north and south from Slough through Windsor to Snow Hill. At Slough the thicknesses of the various beds are taken from the boring at Horlick's Malted Milk factory: as stated above, the thickness of chalk here is exceptionally great, since high beds of Upper Chalk are brought in by the syncline running through Taplow. At the southern end of the section the thicknesses are calculated from the borings at Winkfield and Egham, Snow Hill being in a direct line and approximately half-way between those two points. At Windsor both the Chalk and the Tertiary beds are involved in an anticline, the dips being calculated from the outcrops as about 10° to north and south. But since the chalk at Windsor appears to belong to the lower part of the coranguinum zone, there is probably a pre-Tertiary anticline as well. As pointed out below, the axes of the post-Tertiary folding runs roughly north-east and south-west, and therefore intersects that of the pre-Tertiary movement. The dome-like inlier of Windsor is thus accounted for by the intersection of two gentle anticlinal folds. C. N. B.

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[1] In 'Geology of London.' *Mem. Geol. Surv.*, vol. ii, 1889, p. 196.

[2] White, H. J. O., and Ll. Treacher, 'The Phosphatic Chalk of Taplow,' *Quart. Journ. Geol. Soc.*, vol. lxi, 1905, p. 461.

CHAPTER III.

EOCENE: READING BEDS AND LONDON CLAY.

GENERAL STRUCTURE OF THE EOCENE STRATA.

Our knowledge of the structure of the Eocene Beds of the London basin has been greatly enlarged by the numerous borings for water which have been sunk through them to the chalk in the London area. These borings have demonstrated the thickening of the Eocene strata eastwards which had been previously deduced from a study of the outcrops. The lowest member of the London Tertiaries, viz., the Thanet Sand, is entirely absent from the district now described, and the Chalk is here directly overlain by the next higher division, the Reading Beds, which is not wholly marine like the Thanet Sand. Accompanying the westward diminution in thickness, lithological differences may be noted between the Eocene strata of the present area and those of the country further eastward. Thus the Reading Beds show eastward more strongly the influence of marine conditions and are associated with thick banks of pebbles (Blackheath Beds), which are sparsely, if at all, represented west of London. Again in the ground to the eastward not only is the London Clay itself thicker, but there are also passage beds (Claygate Beds) developed between it and the overlying Bagshot Beds, which are not present in the western part of the area.

The Eocene beds of this area consist of a series of clays, loams and sands, with some beds of pebbles, which have been classified into the five sub-divisions mentioned in Chapter I., p. 4. Of these sub-divisions, the two lower—the Reading Beds and the London Clay—fall within the larger sub-division termed 'Lower Eocene,' while the Bagshot, Bracklesham and Barton Beds, as mentioned in the next Chapter, p. 32, were formerly united under the general term of 'Bagshot Series.'

From the distribution of these sub-divisions, as shown on the one-inch map, and, roughly, on the sketch-map (Fig. 1, p. 2), it will be seen that the older Eocene deposits crop out only in the north and north-western part of the area, and the newer, only in the south and south-east. This structure is due to the tectonic movements which caused the formation of the London Basin.

The date of these movements cannot be determined with accuracy, but was clearly in great part later than the close of Eocene times since all the strata from the Reading Beds to the Barton Beds inclusive are affected by it. On the other hand, it is not probable that any appreciable folding or tilting has taken place in Quaternary times.

The greater part of the area is situated on the northern limb of the London Basin syncline, but evidence is given below for supposing that the south-eastern part lies across the axis of this great flexure. It has elsewhere been recorded[1] that pebbles of

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[1] 'Summary of Progress for 1911.' *Mem. Geol. Surv.*, 1912, p. 32.

Lower Greensand chert occur at the base of the Barton sands, but have not been detected at any lower horizon; the Greensand must therefore have been exposed to denudation in Upper Eocene times; if the source of these pebbles is to be found in the Wealden area, as seems probable, the Wealden uplift must already have begun and some of the beds been denuded. The corresponding syncline may well have been in process of formation at the same time.

This suggestion is borne out by the general tendency of the Eocene beds to thin northwards and westwards away from the synclinal axis. The Reading Beds show clearly a rapid thinning from south to north; the London Clay also probably was thinner in this direction, but so much of it has been removed by denudation, that its original thickness to the north of the Thames in this area is difficult to determine. Evidence of its thinning in a westerly direction is given below. In the Bagshot Beds there is some evidence of attenuation from the centre to the outcrop. The following thicknesses were found in wells:—near the centre of the syncline 123 ft. at Bagshot Orphan Asylum, and 124 at Ottershaw; while a little further out 110 at Wellington College, and 114 at Ascot Electricity Works. Traced from west to east along the northern outcrop the following thicknesses in feet of Bagshot Beds are found: At Bill Hill, Bracknell, 50, Chavey Down 20, Ascot Racecourse 64, Sunningdale 60 to 90. The thinning of the beds is, however, not entirely an original character; wastage of the sands by wash-out along lines of springs would gradually cause the Bracklesham Beds to sink down towards the London Clay; that this is one cause of the thinning is evident from the amount of sand which is continually being removed by springs issuing from the base of the sands along the outcrop. A slight thinning in the same direction is also noticeable in the Bracklesham beds.

The general strike of the beds, as seen on the map, is from south-west to north-east. The dip is hardly perceptible and cannot be measured in any exposure, but the mapping shows that it is towards the south-east. The most convenient line for demonstrating this fact is the base of the Bagshot Beds. The northern limit of the outliers of this series is at 260 ft. at Keep Hatch, 270 ft. north of Bracknell and Ascot, and 280 ft. in Windsor Park. From Wellington College, through South Ascot to Thorpe, the base maintains a fairly even position about 100 ft. O.D. Further to the south-east the level at Chertsey is approximately Ordnance Datum. At Hatch Pit, near Woburn Park, it has been calculated as —50 O.D.[1] At Ottershaw the greatest recorded depth is reached, —70 O.D. At Littleton House, north of the Thames, Bagshot Beds have been doubtfully recorded in a well-section.[2] The base of the Bagshot, according to this account, is at —36 O.D. A second well at the same locality (*ibid.*, p. 131), gives the top of the chalk as —525: comparing this with the figures at Ottershaw —507, and

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[1] Lyons, H. G., *Quart. Journ. Geol. Soc.*, vol. xlv, 1889, p. 637.
[2] 'Geology of London.' *Mem. Geol. Surv.*, vol. ii, 1889, p. 130.

Chertsey —470, it seems certain that the original record was correct.

To the east of the River Wey the beds rise, the base of the Bagshot being 60 O.D. at Oatlands and 72 at Burr Vale.

From these data it is clear that the axis of the syncline runs approximately through Ottershaw, Woburn Park and Littleton. The dip of the northern limb of the fold is 1 in 143 on the west and 1 in 140 between Cooper's Hill and Ottershaw on the east. The southern limb dips at approximately the same angle from St. George's Hill to the axis. This hill itself seems, however, to be on the crest of a minor fold, as the beds on the south-eastern flank resume the southerly dip, as shown by the outcrop of the Barton Beds. A similar result was obtained by Captain Lyons, as shown on his map of the calculated position of the original base of the Barton Beds.[1]

Besides the main folding just described, there appear to be local bucklings: the most important, the Windsor anticline, has already been mentioned; its effect seems to be restricted to a small area. Near Bracknell the outcrops of the Bagshot and Bracklesham beds indicate the presence of a gentle anticline. The base of the Bagshot is at 200 ft. on the western margin of the area, 247 ft. at Bracknell, and 180 ft. at Virginia Water. Corresponding to this arch the Bracklesham beds at Easthampstead attain a slightly higher level than to the west or east.

There appears to be a local uprise of the London Clay in the Sunningdale valley between the station and Virginia Water; for dug wells show many feet of blue clay close to the surface and covered by only a few feet of sand; but it is doubtful whether this clay is London Clay or only a local development of the Bagshot Beds. It was nowhere exposed at the time of the survey and the information is derived from well-sinkers.

H. D.; C. N. B.

Reading Beds.

The series of sands and clays that, in this part of the Thames valley, intervene between the Chalk and the London Clay, were known to the earlier geologists as the Plastic Clay Series. In Part II. of his paper on 'The Structure of Strata between the London Clay and the Chalk,' Prestwich[2] proposed for them the name of the Reading Beds, which has since been adopted. They consist essentially of mottled clays and sands; both constituents are always present, but their relative proportion is exceedingly variable. As a general rule sand predominates in the lower part, clay in the upper, but in some places there is sand again at the top. The lowest member of the series is, however, fairly constant, and is known as the Bottom-bed; it consists of a somewhat clayey sand with much glauconite. At its base and resting directly on the Chalk there is usually a bed of flints, some angular and unworn, and often large, others well rounded and small. These flints are all characterised by a peculiar dark-green crust or coat.

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[1] *Op. cit.*, pl. xxi.

[2] *Quart. Journ. Geol. Soc.*, vol. x, 1854, pp. 75-170, plates i-iv.

These 'green-coated flints' are known over a wide area. In the country to the east of the present district it is rare to find any rolled pebbles at this horizon; there the bed consists essentially of flints, often of very large size, which lie practically in the same position as that occupied before the enveloping chalk was swept away; in the area now described much smaller unworn flints still occupy this original position.

Their persistent occurrence in this position was well known to Prestwich,[1] who describes them as follows:—

> 'Instead of their usual white or black coating, these flints are almost invariably of a deep bright olive-green colour externally; the white outer coating, which is often very thick, seems removed (as though by an acid), and the flint then stained green. The colour, in fact, seems to be not a mere stain, but an actual alteration in the structure of the flint, arising apparently from its having entered into a chemical combination with the iron of the mud or silt in which they became imbedded, forming in consequence a true silicate of iron. There is frequently a thick inner brown stain of the peroxide of iron, but as in the silicate the iron is usually in the state of the protoxide, it would almost appear as though the flints had been imbedded at the sea bottom in a ferruginous mud, and that then some cause, productive of an action on the silica, and a decomposition or deoxidization of the mineral containing the iron, acted simultaneously on the two, and brought them, in presence, into a state in which they would readily combine.'

A microscopic slide of a specimen from Knowl Hill shows the thick inner brown stain, but instead of an outer coat of green flint there is a thin concentrated seam of iron, just below the surface, the outermost part being colourless flint somewhat decomposed and spongy. The sands immediately above the layer of flints are certainly marine. They consist of fairly sharp quartz-grains of medium size, with grains of glauconite and flint. Fish teeth and oysters (*Ostrea bellovacina* Lam.) are said by the workmen to occur at Knowl Hill. At Warren Row, about a quarter of a mile to the north-west of this area, teeth of *Odontaspis elegans* (Ag.) and *Otodus obliquus* ? Ag. can still[2] be found. The origin of both sands and clays above the bottom-bed is less certain, but on the whole they are fluviatile rather than marine. In the paper already quoted,[3] Prestwich remarks that—

> 'Some new and large river action appears to have been opened out from another land by the changes which led to the formation of the Woolwich and Reading Series.'

Speaking of the Reading Beds in common with contemporaneous marine deposits found further east, Mr. Starkie Gardner[4] writes:—

> 'In the direction in which they are deposited and thin out we have evidence of *the presenee of a great river flowing from W. to E.* and scouring and draining a granitic country.'

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[1] *Quart. Journ. Geol. Soc.*, vol. viii, 1852, p. 244.
[2] 'The Country Around Henley-on-Thames.' *Mem. Geol. Surv.*, 1908, p. 73.
[3] *Quart. Journ. Geol. Soc.*, vol. x, 1854, pp. 135-136.
[4] *Proc. Geol. Assoc.*, vol. vi, 1879-1880, p. 92.

More recently Mr. H. W. Monckton[1] remarks:—

> 'This Bottom-bed is marine and the Basement-bed of the London Clay above the Reading Series is marine too, but I believe the whole of the intervening sands and mottled clays to be of freshwater origin.'

The mottled clays alluded to form the typical Reading Beds. In colour they are usually a deep blood-red, mottled with streaks and patches of pale-green: the appearance of this mottling suggests that it is due to a bleaching action on a clay originally all red. Mottled clay from Reading, precisely similar to that which occurs in this area, has been analysed by Dr. Pollard,[2] with the following result:—

SiO_2	53·43
TiO_2	·84
Al_2O_3	18·77
Fe_2O_3	9·42
CaO	·51
MgO	1·40
K_2O	3·39
Na_2O	·54
H_2O at 105	5·55
H_2O above 105	6·59
Total	100·44

Trace of Li_2O, MnO.

FeO cannot be estimated with any certainty owing to the presence of a little organic matter. All iron calculated as Fe_2O_3.

Sand	21·9%
Combined Silica	31·6%
	53·5%

In the present area no fossils have been found in the mottled clay. It is such a deposit as may have been formed in enclosed waters, but no traces of brine or pseudomorphs of salt occur in it. Between the sands and the mottled clay there is sometimes present a bed of laminated sandy grey clay, several feet thick, which locally contains plant-remains—the well-known 'leaf-beds.' Their flora has been examined by Sir J. Hooker, Mr. J. Starkie Gardner and others, but the specimens do not admit of precise identification. The forms generally met with bear a superficial resemblance to plane, willow, maple, lime, poplar, etc., and there is a general agreement that they point to a temperate climate.[3] Hooker considered that the flora in its general facies differed in no important respect from that at present inhabiting the north temperate zone, though the species are of course all different. Mr. Gardner,[4] with more material to examine, came to a similar conclusion; the same writer subsequently obtained a fine specimen of *Taxodium europaeum* Brongn. (*Op. cit.*, p. 92, Pl. xxiv.) from this series at Reading.

In thickness the Reading Beds are fairly constant from west to east, but increase from north to south, as shown in the following table, giving well-records along west to east lines in the north, central, and southern parts of the map:—

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[1] 'Different Types of Geological Deposits.' *Proc. Geol. Assoc.*, vol. xviii, 1903-1904, p. 360.

[2] 'The Country Around Reading.' *Mem. Geol. Surv.*, 1903, p. 36.

[3] Hooker, J. D. 'Note on the Fossil Plants from Reading.' *Quart. Journ. Geol. Soc.*, vol. x, 1864, p. 163.

[4] 'The Eocene Flora.' *Monographs Palæontograph. Soc.*, vol. i, 1872-1882, p. 2.

North.	Ft.	Central.	Ft.	South.	Ft.
Knowl Hill (open section)	60	Wokingham ...	70	Wellington College	104
Slough ... about	54	Hawthorn Dale and New Lodge ...	78	Ottershaw Park...	100
West Drayton ...	60–70	Windsor	70–90	Chertsey	93
Southall	60–70	Staines	80		

EXTENT.—The main outcrop of the Reading Beds crosses the north-western portion of the map, but at Bray disappears below the Thames gravels. Beneath these it has been proved by borings, etc., to be about $1\frac{1}{2}$ miles wide at Bray Wick. It crosses the Thames at Bray, passing under Burnham Abbey and Dorney to Cippenham and Chalvey, and then enters the map to the north, Sheet 255.

There are three outliers of the Reading Beds; the first and largest is that on which the village of Knowl Hill is situated; it is part of a still larger mass extending into the maps west and north of that here described. A second outlier is traversed by the Great Western Railway. The third, quite small, lies a little south of the railway, about four miles to the ENE. of the second.

There are in addition two inliers; the first is about a mile to the south of the main outcrop, and has been laid open by the small stream that flows north through Stud Green and Holyport. The second lies to the east of Windsor and forms the southern end of the ring of Reading Beds that encircles the chalk inlier on which the Castle stands. The rest of the ring, as previously explained (p. 12), is concealed by river-gravels. The Reading Beds are always present beneath the London Clay and have been penetrated in a large number of borings.

RELATION TO THE CHALK.

Sections exposing the junction of the Reading Beds and Chalk do not at first sight reveal the great unconformity between the two formations (*see* p. 14); but an examination of the surface of the chalk beneath the Reading Beds affords evidence of a break in time. This surface, well seen in the pit in Linden Hill Park, described below, usually shows a number of tubular cavities, about 18 in. in length and from one-half to 2 in. in diameter. These cavities are directed vertically downwards from the surface and a few remain vertical throughout their length; but the majority are curved, and some branch obliquely into two or more parts. They are filled with the clay and sand of the lower part of the Reading Beds, and occasional small pebbles from the Bottom-bed. Their origin is a matter of doubt; their form suggests that they may represent the work of excavating sponges. Hudleston[1] thought that they might indicate the roots of marine plants; they are certainly not molluscan burrows.

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[1] 'Excursion to Reading.' *Proc. Geol. Assoc.*, vol. iv, 1876, p. 521.

Near the margin of the Tertiary outcrop, deep piping in the chalk is frequent; it is well seen in the railway-cutting just west of Maidenhead Station and again to the west of Chambers's Farm, where the railway cuts the boundary of the Tertiary several times. Pipes and swallow-holes are also found a short distance within the areas covered by Tertiary deposits; water runs off the clay-beds, but percolates through the basal sands to the chalk; a small swallow-hole has been formed in this way at the eastern side of the brick-pits at Knowl Hill.

C. N. B.

LOCAL DETAILS.

Knowl Hill.—Good exposures of the Reading Beds occur in the brick-pits about Knowl Hill. A small pit situated a little to the north of the point where the Bath Road enters the map, gives the following section:—

			Ft.	in.
Reading Beds ...	Grey laminated clays, somewhat loamy with traces of leaves		1	6
	Red clay		0	2
	Bottom-Bed.	Brown, rather sandy clay with some glauconite	1	3
		Pebble-bed (maximum)	0	6
Chalk.				

At the base of the Bottom-bed in this section pebbles are more numerous than unworn flints and the upper surface of the chalk is riddled with the tubes described above. The thin band of red clay is interesting as showing a forecast of the conditions under which the mottled clay was deposited.

On the northern side of the village are the much larger pits worked by Messrs. F. Warner and Co. The section here shown has been fully described by Mr. Osborne White,[1] whose account of it is reproduced below:—

		Ft.
	5. Yellow and orange sands, occasionally current-bedded .. about	20
	4. Bluish-red mottled clay, with signs of bedding towards the top ...	20
Leaf Beds.	3. Compact, pale blue clay, with loamy partings	2
	2. Laminated blue, grey, and lavender clays, with lenticles of light yellow and brown sand, iron-cemented in places ...	1½
	1. Alternations of ash-grey clay, and sulphur-yellow sand, strongly current-bedded towards the lower part	13

'Three ft. below which a bed of "gravel with oyster shells" resting on the chalk was said to have been encountered.

'The leaf-beds here occupy much the same position in the Reading Series as they do at the type locality. How far they extend beneath the Wargrave outlier is not known, for the brick-yard excavations are rarely carried below the base of the main bed of mottled clay, which, in this district, forms the most economically valuable, as well as the most persistent, member of the series; but they are probably quite local. Few, if any, of the many bands and seams of clay in beds 1 to 3 are devoid of impressions or films of vegetable matter, and those of 1 and 2 are particularly rich in the remains of leaves, stems of reed-like plants, and seed-cases. The yellow sands near the base of the section, also, contain small pieces of lignite. A short search yielded a number of good specimens of leaves, in some of which the impression of cellular tissue could be clearly detected, and it was noticeable that a common variety, of lanceolate form, was alone represented along one fairly well-marked horizon.'

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[1] 'Excursion to Twyford and the Wargrave Outlier.' *Proc. Geol. Assoc.*, vol. xvii, 1901-1902, p. 181.

The basal sands are fairly sharp and clean, but contain many grains of glauconite (see p. 18). The upper sands, bed 5, are somewhat different, the grains being well rounded, and glauconite absent; they are false-bedded and contain little pellets of clay, obviously derived from the underlying mottled series, the surface of which is uneven. The general appearance is suggestive of dune conditions, but there is no certain evidence of wind action. On the opposite side of the main road the northern slope of Knowl Hill shows a greater thickness of these sands, which seem to have encroached on the mottled clay, here only some 6 ft. in thickness.

Three-quarters of a mile to the north-east, on the west side of the Marlow road, there are some abandoned brick-pits; no clear section was visible at the time of the recent survey, but the mottled clays are succeeded by sands similar to those just described.

The only section in the spur running southwards by Weycock Hill is in the railway cutting, where the Bottom-bed is seen overlying the chalk, which is here much piped.

Further north-east, at the bridge for the footpath from Waltham St. Lawrence to Pitlands, a little mottled clay was visible resting on grey clays and sands; the Bottom-bed appears to be continuous for more than half a mile, but except in the railway cutting the boundary of this outlier is obscure.

Where the lane from Heywood Park to Lane House crosses the line, Mr. Whitaker noted 'a shallow hollow of greensand with green-coated flints at the base,' but there was not sufficient material to be mapped as Reading Beds.

A small outlier is shown between the railway and Cox Green: there is no permanent section, but undoubted Reading Bed material was dug out when holes were made for the telegraph poles.

Main Outcrop.—Where the main outcrop enters the map, between Milley Farm and West End, it is more than a mile wide; the northern part is a marshy expanse of flat country, with mottled clays visible in the cuts made for drainage, but near West End the sandy beds form higher ground. East of the little stream between Bear Farm and Beenham's Heath, the same beds form a series of mounds along the lane running north-eastwards towards Shottesbrook. South of Shottesbrook Park the outcrop narrows to less than half a mile and a continuous scarp is formed, which runs through the grounds of Waltham Place to Paley Street. The crest of the escarpment is capped by the pebble-beds at the base of the London Clay, here resting on the upper sands of the Reading Beds. These sands have been dug slightly lower down in some old pits north of Great Wood; and the mottled clays were seen in a temporary excavation by the north-west corner of the Park at Waltham Place. A well sunk at the house, on the top of the hill, in 1894, showed the following section, which must give almost the total thickness of the Reading Beds[1]:—

		Ft.
Reading Beds.	Brown clay, mixed with a little red clay and turning greenish toward the base	52
	Stone, specimen of pyrites	1
	Green sand	5
	Oyster-bed, with flints—some green-coated	3
Chalk.		

At Paley Street and Touchen End the Reading outcrop runs some distance southward up the valley utilised for Bray Cut. In 1869 Mr. Whitaker made out the following section by the bridge[2]:—

'Brown loam of the basement-bed of the London Clay (see p. 27).

Reading Beds.
- A little pale grey and brown clay.
- A little red mottled clay with race.
- Light-buff and mottled sandy clay, with blocks of sandstone (sometimes 2 ft. thick, sometimes with holes like those of a small boring mollusc?), 5 ft. and upwards.
- Mottled clay, hard at top.
- Sand, blackish at top, a few feet shown north of the road.'

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[1] 'The Water Supply of Berkshire.' *Mem. Geol. Surv.*, 1902, p. 91.

[2] 'Geology of the London Basin.' *Mem. Geol. Surv.*, vol. iv, pt. i., 1872, p. 190.

Below this we noted 10 ft. of mottled clay overlying 5 ft. of grey sand. From this point to Thrift Wood the banks are mostly of mottled clay with occasional seams of grey sandy clay.

Further east the ground is again flat and marshy, with no sections. A spur of Reading Beds runs out under the gravels by Shoppenhanger's Farm and the golf course, within which mottled clay was noted by Kimber's House and in the lane east of Cox Green.

By Bray Wick and Holyport the Reading Beds disappear beneath the Thames gravels; but by the cross-roads between Salt Hill and Chalvey red mottled clays were exposed in the floor of a large gravel pit.

In 1887 a trial boring made by the Grand Junction Water Company at Boveney gave the following section[1]:—

		Ft.
London Clay.		
Reading Beds, 78½ ft.	Grey marl, clayish (mottled)	10
	Grey and red marl, clayish (mottled)	6
	Wet stiff brown sand	19
	Brown clay	½
	Wet stiff brown sand with stones	18
	All coloured stiff clay (mottled)	22?
	Small flints with clay, one large flint	3?
Soft chalk and small flints.		

Inliers.—In the small inlier south of Money Row there are no sections; but mottled clay can occasionally be seen in the banks of the little stream.

The remaining surface outcrop is at Windsor, on the south side of the Castle Hill, but the boundaries, especially that between the Reading Beds and London Clay, are obscure. Those shown upon the map are largely based upon the work of Mr. Lundy, who for a long time collected information from temporary openings in the streets of Windsor: many of his particulars have been published,[2] and some of his specimens are still preserved in the museum at the Royal Albert Institute, Windsor; a tracing of his manuscript map was sent to Mr. Whitaker by Mr. F. Drew, of Eton, and our lines have to some extent been taken from it.

In 1910 and 1911 new buildings were erected at the Victoria Barracks; Mr. Yates, the Clerk of the Works, informs us that at the western end gravel occurred, but at the eastern end Reading clays came up to the surface.

Mr. Whitaker notes the following temporary sections which he saw in 1869[3]:—'Close to the northern end of Sheet Street the excavation for the foundation of a house, on the western side of the road, laid open grey and yellowish clay; whilst a larger opening lower down on the other side, 60 yds. or more from the top of the street, was in red, blue, and variously coloured mottled clays.'

There are no permanent exposures, but a comparison of the well sections gives the following generalised section:—

		Ft.
London Clay.		
Reading Beds, 85 ft.	Mottled clay...	45
	Sand	10
	Mottled clay...	25
	Green sand and flints (Bottom-bed)	5
Chalk.		

C. N. B.

London Clay.

The main mass of the London Clay consists of a stiff clay, grey or blue in colour, but weathering reddish-brown. This superficial discoloration, which is due to oxidation of marcasite disseminated in minute grains through the blue clay, extends to a depth of a few feet only, the clay below being mottled and streaky and at an average depth of 20 ft. unaffected by weathering.

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[1] 'Geology of London.' *Mem. Geol. Surv.*, vol. ii, 1889, p. 8.

[2] *Proc. Windsor and Eton Sci. Soc.* 'Presidential Address.' 1886, Windsor, 1887, pp. 11-18.

[3] 'Geology of London.' *Mem. Geol. Surv.*, vol. i, 1889, p. 180.

The clay is homogeneous through most of its mass, but is interbedded with layers of sand at its base and top. Scattered through the main mass are irregular layers of concretionary discoid and ovoid cement-stones or septaria, concretions of pyrites and occasional selenite crystals. The cement-stones consist of argillaceous limestone and are traversed by numerous cracks filled with crystalline calcite of varying colours and velvety lustre; in the upper part of the clay they frequently contain fossils. The pyrites does not, as a rule, occur in definite layers, but as isolated masses of irregular shape; to its decomposition in the presence of calcium carbonate may be attributed the formation of selenite.

The above description applies to the great mass of the London Clay, but at its upper and lower limits there are beds of a different lithological character. The 'Basement Bed,' so named by Professor Prestwich, consists of sandy loam and occasional beds of sandstone with a well-marked pebble bed; it is usually fossiliferous. At the top of the clay somewhat similar beds recur, though pebbles are absent, and with the return of sandy conditions the fauna of the basement bed comes in again.

The London Clay is of marine origin, except that the Basement Bed indicates a transition from estuarine conditions, and therefore marks the beginning of a submergence of the land. The Basement Bed, both in its lithology and in the type of its fossils, is a characteristic shoal-water deposit, current-bedded, composed of alternations of sand and clay and containing banks of flint pebbles: among its more common fossils are species of *Ostrea*, *Modiola*, *Panopaea*, *Pholadomya*, *Cytherea*, *Aporrhais* and *Natica*. The subsidence continued until it was neutralised by sedimentation when a depth of some hundred fathoms was reached; this depth being indicated by the Foraminifera,[1] Echinodermata, Cephalopoda and other molluscs.[2]

The recurrence of the sandy facies toward the top of the clay denotes the beginning of an emergence which culminated when the overlying Bagshot sands were deposited.

The climate appears to have been temperate at first, gradually changing to sub-tropical as noted by Professor Owen,[3] Sir J. D. Hooker[4] and others.

Extent.—In Sheet 269 the actual outcrop of the London Clay covers an area of about 36 square miles. It is overlain by the Bagshot Series along the southern half of the district and over some 70 square miles, is covered by superficial deposits, consisting mainly of the river-gravels of the Thames. In thickness it shows a steady increase from west to east, as indicated by deep borings.

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[1] 'Geology of the London Basin.' *Mem. Geol. Surv.*, vol. iv, Part I., 1872, p. 275.

[2] Prestwich, J. *Quart. Journ. Geol. Soc.*, vol. iii, 1847, p. 374.

[3] *Palæontographical Soc.*, 1849.

[4] 'Himalayan Journals,' vol. i, 1854, p. 1.

Near its western margin the total thickness does not exceed 300 ft., being 256 ft. at Bearwood, 288 ft. at Wellington College, and 299 ft. at Wokingham: tracing it eastward we find the following thicknesses:—Ascot 349 ft., Sunningdale 360 ft., Ottershaw 371 ft., Chertsey 386 ft., while at Esher, a little to the east, it exceeds 400 ft.

H. D.; C. N. B.

LOCAL DETAILS.

Basement Bed.— The basement-bed can be followed continuously where the junction of the London Clay with the Reading Beds is not obscured by drift, along the whole distance, some six miles in a direct line. Sections, however, are by no means plentiful. The actual junction is marked by a thin seam of pebbles followed by a few feet of loamy sand with shells; above this comes a fairly thick band of pebbles, the outcrop of which can easily be traced at the surface. The line thus fixed enters the district from the west at Hungerford, whence it follows a somewhat winding course north-east by east to Waltham Place.

The basement-bed was proved in a well 18 ft. deep at the west side of Honeys Park; Mr. Clark, who sank the well, states that the section ended in greenish sand full of water, above which was a pebble bed with oyster shells, overlain by ordinary London Clay. At the Brewery at Shurlock Row the following section was proved beneath 16 ft. of surface material[1]:—

		Ft.
Basement Bed.	Green loam and shells	4
	Sand rock	2
	Sand and pebbles with water	4
Reading Beds.	Mottled clay.	

Round Paley Street and Touchen End the boundary winds along the sides of several little valleys, and in Bray Cut, near the latter locality, it is traceable for some distance to the southward of the general trend. The Cut, made in 1819 for drainage purposes, revealed a good section, but as it is now to some extent overgrown and difficult of access, the descriptions of early observers may be quoted. Mr. Polwhele writes[2]:—'In the cut made to drain Ruscombe Lake the following section is shown near the bridge on the road from Paley Street to Cox's Bridge (now Buck Bridge, on the road to Binfield):—

		Ft.	ins.
	Clayey drift	2	0
	London clay	5	0
Basement Bed.	Loam with layers of clay and shells, here and there pebbles	6	0
	Pebbles and oysters	1	0
	Sand, in places hardened into stone	2	0
	Bed of *Ditrupa*	0	2

'A little to the west several pebble-beds may be seen in the section. By the bridge at Paley Street the mottled plastic clay of the Reading Beds is capped in places by the bed of *Ditrupa*, here cemented into stone, and over

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[1] 'Water Supply of Berkshire.' *Mem. Geol. Surv.*, 1902, p. 88.

[2] 'Geology of Parts of Middlesex, etc.' *Mem. Geol. Surv.*, Sheet 7, Old Series, p. 47, 1864.

CASCADE AT TOUCHEN END.

which a reddish and then a yellowish clay come on but no pebble bed.' Just south of this bridge Mr. Whitaker in 1869 made out the following section[1]:—

			Ft.	in.
London clay.		Brown clay with a few pebbles at the bottom.		
		Scattered line of pebbles.		
	Basement bed.	Whitish loam with shells	1	4
		Sandstone with shells (chiefly of *Ditrupa*)	0	2
		Grey sand, with shells of *Ditrupa* just at the bottom	2	6
		Brownish clayey sand, passing into the bed below	1	0
		Grey sand, rather more clayey than that above, with a layer of *Ditrupa-shells* close to the bottom and a few shells just below this layer	1	0

'Plastic clay of the Reading Beds (see p. 23).'

During the present survey a few fossils were obtained here, but gave no additions to Prof. Prestwich's[2] list of specimens collected by Warburton.

The sandstones are strongly developed and are exposed in the bottom of the watercourse for about one mile. They are hard and grey with calcareous cement; under the microscope they are seen to consist of minute angular grains of quartz, with occasional flakes of mica and grains of glauconite, in a paste of calcareous matter. These rocks form outstanding ledges in the little gully, over one of which, about a quarter of a mile south of Paley Street Bridge, is the waterfall shown on Plate II. . in some parts *Ditrupa plana* (J. Sow.) forms the bulk of the rock, but in others it is absent.

From Touchen End the boundary runs northward to Thrift Wood and then turns to the east past Stud Green and Holyport, where it disappears beneath the deposits of the Thames. At Stud Green are some brick-pits, now abandoned and partly filled with water. Mr. Whitaker quotes the following section from Mr. Polwhele's notes:—

	Ft.
'Brick clay, sandy	5
Bands of sandstone	1
Brick clay	9
Mottled clay and blue clay	

'The *Ditrupa plana* was found in a basement bed of the London Clay,' and adds, 'It is hard to say where is the division between the London Clay and the Reading Beds here, but I should think that only the first two beds belong to the basement bed of the former.'[3]

The sandstones are also visible in the stream-course where the Stud Green lane turns off from the main road between Holyport and Touchen End.

Where concealed beneath the Thames gravels, the boundary between the London Clay and Reading Beds is still somewhat uncertain, but evidence has been obtained from wells and borings showing that the line adopted on the former map (Sheet 7) required modification. Much of this evidence has already been given in the description of the Windsor Inlier, where it is shown that the Reading Beds circle round the chalk and are quite detached from the main outcrop. The boundary of the main mass of the London Clay continues its normal course, crossing the Thames somewhere near Queen's Eyot and passing just south of Dorney to Chalvey and Slough. At Oakley Court a well (see p. 97) proved the existence of 25 ft. of London Clay; on Boveney Common the two trial-borings already referred to showed thicknesses of 20 and 30 ft. respectively at the southern and eastern corners. At Chalvey the Reading Beds are visible at the surface, while at the Old Waterworks,

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[1] *Mem. Geol. Surv.*, vol. iv, 1872, p. 297.

[2] *Quart. Journ. Geol. Soc.*, vol. vi, 1850, p. 267.

[3] 'Geology of London.' *Mem. Geol. Surv.*, 1889, p. 179.

Slough, there is 20 ft. of London Clay above them. In Horlick's well at Slough (see p. 105) the Reading Beds show their average local thickness of 54 ft., and as there is no London Clay in the section, we have drawn the boundary line through this point.

As mentioned above (p. 24) a small inlier of Reading Beds has been mapped between Mount Scipett and Touchen End. Mr. Polwhele found the basement bed of the London Clay near the southern point of the inlier, for he notes:[1] 'In some ferruginous sand thrown out of a pond near a cottage, a quarter of a mile west of Mount Scipett, I saw a quantity of *Ditrupa* and a few oyster shells.'

Main Mass.—In the lower part of the main mass of the London Clay sections are practically absent; a small brick pit is, however, still open in this portion near the southern margin of Billingbear Park. Here 10 ft. of stiff brown clay, with a thin band of pebbles are exposed, and the clay is said to have formerly been dug to a total depth of 30 ft. By Dairy Farm, north-east of Winkfield, is an abandoned pit, where septaria are numerous. There are poor exposures in the banks of the stream south of Oakley Green between New Lodge and St. Leonard's Hill; septaria are abundant, but have not yielded fossils. Round Windsor the clay was formerly worked for bricks, as, for instance, at Clewer and just east of the Cavalry Barracks at Spital, but no sections were visible at the time of the survey.

C. N. B.

Bracknell Area.—In the upper part of the formation the exposures are much more numerous. The clay is worked for bricks in many large pits near Bracknell, especially between that town and Wokingham. There is little variation in the several pits: they all show yellow and brown oxidised clay at the top, except where covered by Bagshot Sand; and contain fossiliferous concretions or septarian nodules. The list of fossils, given on page 31, shows a similar assemblage of forms at each pit with a few exceptional occurrences at Amen Corner pit, including *Cyprina scutellaria* (Lam.) and *Vermetus bognoriensis* (Mant.).

Near Beanoak Farm, the Victoria Brick and Tile Company work the clay at the western end of Buckhurst Hill. The clay is overlain by Bagshot Sands, the junction being sharp without any passage-beds; neither is there any sign of passage-beds at Amen Corner, where the following section is exposed in the Binfield Brick and Tile Company's pit:—

		Ft.
	Soil	1
Bagshot Sand	White sand	5
	Yellow sand	2
London Clay	Yellow clay	10
	Blue clay	

At the same Company's pit near Bracknell the section is:—

		Ft.
	Soil	3
London Clay	Mottled blue and brown clay	6
	Liver-coloured and drab clay	3
	Grey-blue clay	6
	Blue clay	

Scattered irregularly through the above are occasional septarian nodules, but there were none in 10 ft. of blue clay traversed by a new trench in the middle of the pit. Selenite crystals are abundant and the clay has yielded many fossils, *Cyprina scutellaria* (Lam.) being characteristic.

The clay in the adjoining pit worked by the Down Mill Brick and Tile Company contains a slightly different fauna, probably marking a small change of horizon. At the north side of the pit the section was:—

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[1] 'Geology of Parts of Middlesex, etc.' *Mem. Geol. Surv.*, Sheet 7, Old Series, 1864, p. 48.

		Ft.
	Soil	1
London Clay	Subsoil	2
	Grey-blue clay weathering yellow and brown, mottled and streaked	6
	Drab clay with green and dark grey layers, septaria and fossil wood	12
	Dark blue-grey clay without septaria	5

On the south side was the following section:—

		Ft.
	Soil	1
London Clay	Subsoil	2
	Blue clay weathering yellow and ochreous	5
	Drab clay with discoid septaria	7
	Slate-coloured clay	6

Near the base is a bed of grey-green pyritic clay with curious vermicular marks and ridges, which are probably worm borings. Brick-earth was dug in two large pits, one on each side of Folder's Lane (Bracknell), but was worked out many years ago and the pits are flooded. Many septarian nodules may still be found, which often contain fossils, gasteropods being particularly abundant. A section showed 4 ft. of coarse quartz-sand stained reddish-brown, with irregular pockets of gravel, overlying 10 ft. of reddish loamy clay. There is another pit about half a mile north of the town, in Gough's Lane, still worked for bricks and tiles, where the junction of the London Clay and Bagshot Sands is exposed. The section shows alternating beds of buff and yellow sand with pipe-clay (Bagshot Beds), resting on 12 ft. of slate-coloured London Clay. Mr. Polwhele notes that 'in the brickyard south of Warfield the upper bed of the London Clay, with septaria full of fossils, may be seen, and above it the passage bed from this formation to the overlying Bagshot Sand.'[1]

Ascot Area.—No more sections in the clay are met with until we reach Ascot, where the Brick Company's pit at Wood End shows 14 ft. of yellow, liver-coloured, and blue clay, fossiliferous and containing septarian nodules and selenite. H. D.

Windsor Park.—In Windsor Park there are traces of a passage from the London Clay to Bagshot Sands. About a quarter of a mile south-west of Sandpit Gate a ditch showed pale-grey sand somewhat loamy passing down gradually into bluish clay with iron-mottling and a thin band of ironstone. About a quarter of a mile north-east of Bishop's Gate Mr. Whitaker says that 'a pit more than 15 ft. deep showed thin alternations of brown and light-coloured sand with pale-grey clay [Claygate Beds], the lower part being more of a brown loam, whilst below there seems to be clay.'[2] This section is now much obscured.

Egham.—Further east the slopes of Cooper's Hill, much affected by land slips, show London Clay, passing up into Bagshot Sands, which form the top 20 ft. or thereabouts. In a small pit, now much overgrown, near the northern point of Runnymede Park, the septaria are full of *Ditrupa plana* (J. Sow.) and a bryozoon *Membranipora eocena* (Busk.) and one small gasteropod was found. There are some old pits, now grassed over, on the slope of Egham Hill, on the south side of the main road, near the nineteenth milestone from Hyde Park Corner. These were described by Warburton,[1] who found many of the commoner fossils of the London Clay here

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[1] *Mem. Geol. Surv.*, vol. iv., part I, 1872, p. 298.

[2] 'Geology of London.' *Mem. Geol. Surv.*, vol. i, 1889, p. 251

South of Egham.—Owing to a slight southerly dip the top of the London Clay descends the river-cliff between Egham and Stroude until it passes beneath the gravels. It remains thus concealed until Oatlands is reached, where a change of dip brings it to the surface between two terraces of river-gravel, the outcrop extending to Walton-on-Thames.

Walton Railway Cutting.—In the railway cutting between Weybridge and Walton the London Clay was exposed to the east of the bridge by which the Walton Common road crosses the line. This section has been described in great detail by Mr. Hudleston.[2] He noted that the typical London Clay was succeeded by alternations of clay and grey sand, beds which we regard as forming a transition from London Clay to Bagshot Sand and refer to the Claygate Beds (see below p. 38).

From the typical London Clay a specimen of *Membranipora lacroixii* (Busk.) has been recorded.[3]

North of the Thames.—The London Clay crops out from beneath the river deposits at two localities: about Richings Park and Thorney it is exposed between the gravel terraces and the alluvium of the Colne over a considerable area, but there are no sections. In 1902 Mr. Howe saw blue and brown clay on the eastern side of the lake in Richings Park. North of Thorney the same observer found some 5 ft. of London Clay exposed in the banks of the Grand Junction Canal at the point where it crosses the northern margin of the map, but the outcrop is too small to be shown.

Further to the east the valley of the Crane north of Cranford has been cut down through the brickearth and gravel to the London Clay; Mr. Howe was able to map it from the surface evidence, but there are no exposures worth noting.

A number of borings at West Drayton show the presence of 60 to 80 ft. of London Clay beneath the gravels.

When the Staines Reservoir was made, the whole of the superficial sands and gravels was removed, and the London Clay exposed. In a manuscript preserved in the Survey Office, Messrs. E. T. Newton and T. I. Pocock give the following list of fossils identified on the spot:—

Wood and Lignite.
Avicula (? media, *J. Sow.*).
Cardium (? nitens, *J. Sow.*).
Cyprina planata, *J. de C. Sow.*
Nucula bowerbanki, *J. de C. Sow.*
Nuculana [Leda] amygdaloides, *J. de C. Sow.*
Ostrea sp.
Pholadomya margaritacea, *J. Sow.*
Teredo (boring in wood).
Aporrhais sp.
Cassidaria sp.
Pleurotoma sp.
Pyrula sp.
Nautilus (? imperialis, *J. Sow.*).
Nautilus (? regalis, *J. Sow.*).
Lamna macrota, *Ag.*
Shark vertebra.

A large number of trial-borings have recently been put down in the neighbourhood of Staines by the Metropolitan Water Board in connection with the new reservoir scheme. The records show that to the south of Ashford the London Clay beneath the gravel is sandy to a considerable depth. These beds form a passage to the Bagshot Sand, proved at Littleton, and correspond with the Claygate Beds further east.

Outliers.—Several small outcrops of London Clay are shown about Knowl Hill, in the north-west corner of the map. They are either outliers or portions of outliers which extend into the maps to the north and west.

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[1] *Trans. Geol. Soc.*, series II, vol. i, 1824, p. 49.
[2] *Quart. Journ. Geol. Soc.*, vol. xlii, 1886, pp. 154-155.
[3] *Proc. Geol. Assoc.*, vol. ix, 1886-7, p. 540.

In one of these, about half a mile west-north-west of Knowl Hill Church, the Basement Bed has been noticed; small patches of the pebble-bed have been detected crowning Knowl Hill and a small wooded ridge close to the road to Great Marlow.

C. N. B.

List of Fossils from the London Clay.

(These fossils were collected during the recent survey and are preserved in the Palæontological Department of the Museum of Practical Geology.)	Down Mill Brick Company's pit, 1000 yards west of Bracknell Station.	Pit on west side of Folder's Lane, Bracknell.	Pit on east side of Folder's Lane, Bracknell.	Pit east of Amen Corner, 1⅛ miles west of Bracknell Station.	Pit at Woodend, 1½ miles north of Ascot Racecourse.
Membranipora eocena (*Busk*)	—	—	—	x	x
Ditrupa	x	x	x	—	—
Arca impolita (*J. de C. Sow.*)	x	—	—	—	—
Corbula ?	—	—	x	—	—
Corbula globosa ? (*J. Sow*) ...	—	—	—	—	x
Cultellus affinis ? (*J. de C. Sow.*) [Solen *Auct.*]	x	—	—	—	—
Cyprina scutellaria (*Lam.*) ...	—	—	—	x	—
Meretrix suessoniensis (*Watelet*)	x	—	—	x	—
,, sp.	—	x	—	—	—
Modiola depressa *J. Sow.* ...	—	—	—	—	x
,, elegans *J. Sow.* ...	x	x	—	x	x
,, simplex *J. Sow.* ...	—	x	—	—	—
Ostrea sp.	x	—	—	—	—
Pectunculus brevirostris ? *J. de C. Sow.*	x	—	—	—	—
Pinna affinis *J. Sow.*	x	x	—	—	—
Protocardia nitens (*J. Sow.*) ...	x	x	x	x	x
Pseudamusium corneum (*J. Sow.*)	—	—	—	—	x
Pteria media (*J. Sow.*) ...	x	x	—	—	x
Tellina ?	x	—	—	—	—
Teredina personata (*Lam.*) ...	x	—	—	—	—
Teredina sp.	—	—	—	x	—
Cassis ambigua (*Sol.*) ...	x	x	—	—	—
,, nodosa (*Sol.*)	x	x	x	x	—
Chrysodomus antiquus ? (*Sol.*)	x	—	—	—	—
,, errans ? (*Sol.*) ...	x	—	—	—	—
Natica labellata *Lam.* ...	x	x	x	x	x
Pisania cymatodis (*Edw.*) ...	x	x	—	x	—
Pisania sp.	—	—	x	—	x
Pleurotoma prestwichi *Edw.*	—	x	—	—	—
Pyrula angulata *Edw.* ...	x	—	—	—	—
,, smithi (*J. de C. Sow.*)	—	—	—	x	—
Ringicula ringens (*Lam.*) ...	x	x	—	—	—
Rostellaria lucida *J. Sow.* ...	x	—	—	x	x
Solarium ?	x	—	—	—	—
Solidula simulata (*Sol.*) ...	x	—	—	—	—
Trophon tuberosus (*J. Sow.*)	x	—	—	—	—
Vermetus bognoriensis (*Mant.*)	—	—	—	x	—
Nautilus sowerbyi ? *J. de C. Sow*	x	—	—	—	—
Odontaspis elegans (*Ag.*) ...	x	—	—	x	—
Fish scale	x	—	—	—	x
Fish vertebra	x	—	—	—	—

CHAPTER IV.

EOCENE (*continued*): BAGSHOT, BRACKLESHAM AND BARTON BEDS.

CLASSIFICATION.

The sands, clays and pebble beds that lie above the London Clay in this area form the highest Eocene deposits of the London Basin. For some time they were grouped together as the 'Upper Marine Series' and under this name their distribution was partially shown on the first and second editions of Greenough's map. Their true stratigraphical position was shown by Warburton[1] in 1821, who proposed the name of 'Bagshot' for them. In 1847 Prestwich subdivided these beds into Upper, Middle and Lower Bagshot, and with slight modifications these divisions were adopted by the Geological Survey on the Old Series map Sheet 8. Prestwich also showed their relations with beds of the Hampshire and Paris Basins, and corrected the erroneous view that the London Clay and Barton Beds of these basins were contemporaneous. Considerable work has been done on these beds by Messrs. Monckton and Herries and by Dr. Irving which will be discussed in the following pages. Adopting in the main the result of their work in the present Memoir and on the map we restrict the term Bagshot Beds to the lowest of the three divisions; the middle division being now classed as the Bracklesham Beds and the upper as the Barton Beds.

BAGSHOT BEDS.

Lithological Characters.—The Bagshot Beds of this district are of fairly uniform composition and almost always show current-bedding. The dominant component is white and yellow quartzose sand, but there are occasional small flakes of mica and felspar and more rarely tourmaline and zircon; the sand-grains are normally small and well-rounded. The colour varies locally through shades of yellow and pink to brown, liver-colour and crimson. Interspersed in the sands, at irregular intervals, are thin layers of fine-grained grey and white silty clay and pipe clay, ranging from ¼ in. to 3 in. in thickness. A feature of these seams is the frequency with which they have been broken up by current-action, fragments of the originally continuous bed being found at all angles, though still arranged in a well-marked band. A further stage in their disintegration may be recognised in the little pellets of clay scattered at random through the sand.

Iron oxide in some form may usually be found at every section; in some cases it occurs mainly as a coating on the individual grains, giving rise to bright colouring; in others it forms distinct layers and hollow nodules or concretions. The layers occur chiefly at the junction of the sand and films of clay; sometimes there is merely a thin layer of iron oxide both above and below a clay film; in other cases the iron has been deposited in sufficient quantity to form a seam of ironstone with or without visible traces of the clay remaining. The nodules occur as hollow concretions, rarely round, more frequently reniform, but mostly in box-like rectangular masses. Pebble Beds occur in the Bagshot Beds, mostly as local and discontinuous lenticles. One band, however, near the base, appears to be fairly continuous; it is composed of well-rounded black flint pebbles set in a matrix of sand, the whole showing marked false bedding. A full account of these beds will be given in the description that follows (pp. 34-40); but it may be here stated that no pebbles of Greensand chert have been met with in these beds, suggesting that at the time of their formation the Lower Greensand, in the great Wealden anticline, had not yet been exposed to denudation.

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[1] *Trans. Geol. Soc.*, series II, vol. i, 1824, pp. 48-52.
[2] *Quart. Journ. Geol. Soc.*, vol. iii, 1847, p. 378.

A deposit of unusual character occurs in the Bagshot Beds at the top of the division immediately underlying the Bracklesham Beds in the area around Brimshot, just north of Chobham village, and also near the church by Long Cross House. It consists of exceedingly fine-grained siliceous material of milk-white colour which is so light that even a gentle breeze will blow it about in clouds. This wind-borne material imparts a high polish upon the stones which lie on the surface of adjacent heaths and moors.

Small fragments of lignite, and, not uncommonly, thin beds and lenticles containing comminuted plant-remains have been noted, and a few indeterminable fossils have been found; the age of the beds can be inferred only from their stratigraphical position.

The characteristics described above serve to distinguish the Bagshot Beds from those of the Barton Beds, to be described later. These beds attain their maximum thickness in the central parts of the district, but do not there exceed 120 ft. While they maintain a fairly constant thickness from east to west, they thin towards the north along the Ascot Hills to as little as 20 ft.

Relation to London Clay.—Prestwich considered that the Bagshot Beds were everywhere 'in distinct and conformable superposition to the London Clay '.[1] While this view is correct for part of the present area, there are indications of unconformity between the two on the northern and western margins of the basin. For while on the east we find a conformable sequence with passage-beds, traces of which have been noted as far west as Windsor Park; on the west, as at Amen Corner, there is an abrupt change of sedimentation with indications of some erosion of the clay before the sands were deposited; this unconformity increases till in the Hungerford District,[2] 40 miles west of Windsor, the Bagshot Beds rest directly on Reading Beds.

Soil.—The soil formed by these sands is poor and dry, and requires to be heavily manured before it will yield a good crop.

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[1] *Quart. Journ. Geol. Soc.*, vol. iii, 1847, p. 380.

[2] 'Geology of the country around Hungerford.' *Mem. Geol. Surv.*, 1907, p. 68.

It is in consequence largely uncultivated, and characterised by open heaths and thick woods. Prof. Prestwich[1] has described the area formed of the sands as follows, 'they form some of the most pleasing scenery in the neighbourhood of London . . . comprising the well-known parks and grounds of . . . Painshill, Burwood, Oatlands, Woburn, Botley, St. Anne's Hill, Virginia Water . . . and Easthampstead. . . . Just on the borders of the clays and sands are many pleasant villages embosomed in woods, in which the oak and elm of the clays are interspersed with the firs and larches of the sands. This is the general character of the country in most parts of the zone of outcrop of the lowest strata of the Bagshot Sands at their junction with the London Clay.' The sands also form wide tracts of open heath with occasional pine woods as on parts of Chobham Common and south of Dunford Bridge, in this aspect resembling the scenery of the Barton Beds.

H. D.; C. N. B.

Local Details.

Main Outcrop.

Easthampstead Park.—At the western end of the main outcrop in the neighbourhood of Easthampstead Park there are several sandpits in the Bagshot Beds; one, opposite the Pinewoods Sanatorium, is worked in current-bedded yellow sand, while similar sand forms much of Easthampstead Park. In Easthampstead village a pebble-bed, near the base of the sands, is seen in some gardens at the back of the school, alongside a coppice in the Rectory grounds, and at several other points in the neighbourhood; a grave in the churchyard revealed the following section:—

	Ft.
1. Dark soil	1
2. Yellow loam	1 to 1¼
3. Black pebbles in sandy loam	2½ to 3
4. Light-yellow sand	7+

The pebble-bed (3) is exposed again near 'The Green Man,' where it occurs at a few feet above the London Clay, and its pebbles are strewn over the adjacent field.

Bracknell.—The bed is traceable thence to Bracknell, where it caps the cutting east of the station,[2] and the pebbles are seen in many of the gardens in the town; in one of which the underlying sand (4), about 10 ft. thick, occurred between it and the London Clay. The same pebble-bed was met with in the main sewer along High Street; and was dug for road metal near the railway, in Church Road and at Wick Hill. In 1910 it was exposed in the grounds of Holly Spring, where it underlies about 10 ft. of the plateau gravels and sand.

At Bill Hill, Old Bracknell, there is a large pit showing about 20 ft. of silver and pale-yellow sand, with many seams and pellets of pipe-clay, and containing iron-concretions and shelly clay-nodules. Seen as a whole the sand is well bedded, but each band usually shows strongly-marked current-bedding. A pit further up the hill shows the highest beds of the Bagshot capped by the Bracklesham Beds.

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[1] *Quart. Journ. Geol. Soc.*, vol. iii, 1847, p. 378.

[2] This cutting has been described by Dr. Irving, *Quart. Journ. Geol. Soc.*, vol. xli, 1885, pp. 492-510, and by Mr. Monckton, *ibid.*, vol xlii, 1886, pp. 402-417, who differ in their interpretation.

At Borough Green a pit near Firlands exposes 18 ft. of the typical Bagshot Sand showing exceptionally well the characteristic false-bedding, seams and pellets of pipe-clay, flakes of white mica and grains of felspar.

Chavey Down.—About Harmans Water and Whitmore Bog the erection of new houses and the sinking of several wells have shown the whole area to be on the outcrop of the Bagshot Sand, which is often of considerable thickness. As the area is largely bog, it was mapped as London Clay during the former survey, but the error was pointed out by Dr. Irving.

About Chavey Down there are four pits which taken together show the characters of almost the whole of the Bagshot Beds. The lower portion is exposed in the pits at Lilyhill and the neighbouring Clinton Hill, while the upper part and the overlying Bracklesham Beds are laid open in the two pits at the north end of the hill.

South of Warfield Park the top and base of the Bagshot Beds are sufficiently close together to enable the thickness to be estimated accurately; for the base of the Bracklesham Beds lies at O.D. 280, while, near by, the top of the London Clay is at O.D. 250; thus giving a total of only 30 ft. for the Bagshot Beds. Further north the top and base can again be accurately fixed and the figures show that the thickness does not exceed 20 ft. Dr. Irving first called attention to this thinning in a northerly direction. The thinning, however, may be due neither to original attenuation nor to post-Bagshot denudation but to the gradual outwash of the sands from between the beds of clay which underlie and overlie them.

South of Chavey Down, between Bracknell and Ascot, on both sides of the railway the sands form a wide, flat, water-logged expanse characterised by bogs and ponds, such as Harman's Water, Whitmore Bog, Ascot Marsh, and Englemere Pond. At one time the whole expanse was more or less covered with peat, which was dug at Ascot Marsh. It is on this flat land that the small streams rise which have severed the Ascot Hills from the main outcrop of the Bracklesham Beds. After crossing Sunninghill Ridge there is a second marshy area formed of these sands, stretching from Sunningdale to Virginia Water station. It is still largely covered by moss and many parts are dangerously swampy.

South of the meeting of the five roads at Chavey Down there are two deep sand-pits showing the following section:—

	Ft.
Soil	1
Yellow-red sand and pipe-clay laminae	3
White sand and pan	2
Alternating sand and pipe-clay, with ferruginous concretions ...	12
Current-bedded white and brown sands	10

Another section near the reservoir on Chavey Down showed 12 ft. of current-bedded variegated sands with seams of pipe-clay overlain by Bracklesham Clay.

Ascot Area.—A pit south of Barnhill shows 20 ft. of white and yellow sand strongly current-bedded and crossed by several small faults; similar sand is seen in the pit near the Royal Kennels.

In Ascot itself numerous wells have been sunk in the Bagshot Beds, the greatest thickness proved being 74 ft., at the Grand Stand.

Sunninghill.—Between Sunninghill and Coworth Park one or more beds of clay come on in the sands; the most important, near Beggars Bush, is 4 ft. thick and was worked for bricks. It was found while planting trees in the grounds of Tittenhurst Lodge, but was absent at Titness Park and Coworth Park. It occurs again to the south at Broomhall Farm, but was absent in the boring at the Ascot Gas Works. At Sunninghill a pebble-bed has been encountered in the wells at Amhurst Lodge and Silwood Lodge; it outcrops near the lake at the latter locality and again near Harewood Lodge and Blacknest. Northwards, a pebble-bed at apparently the same horizon occurs near the great pond in Sunninghill Park.

Cranbourne Chase.—From Sunninghill Park a narrow spur of Bagshot Beds runs northwards into Windsor Forest and widens to form the high ground round Cranbourne Chase. A few old pits show yellow sands with seams of pipe-clay, but no pebble-beds were seen. Many springs are thrown out at the junction with the London Clay, and in the ditches traces of passage-beds were found. At Woodside about 25 ft. of Bagshot Beds is present, and at Holly Grove, 30 ft.

Virginia Water.—In the Virginia Water district the main outcrop of the Bagshot Beds widens considerably, though its continuity at the surface is interrupted by several outliers of Bracklesham Beds and plateau gravels and by the river gravels of the Bourne. To the north of the lake a large rudely quadrangular area of Bagshot Beds stretches through the Park to Bishop's Gate and New Egham. A pebble-bed near the base of the subdivision is present over much of the ground; on the south side of Obelisk Pond a section shows it resting on 20 ft. of silver and orange sands; current-bedding is here exceptionally well seen (Plate III.); the sand is fine-grained and contains a considerable amount of felspar and mica; dispersed through it are thin seams and pellets of pipe-clay. Near Scarlet Oak Plantation a pebble-bed, presumably the same, has been dug for road stone. H. D.

New Egham.—A similar pebble-bed covers so large an area about New Egham that its outcrop has been shown on the map. A little to the east, and presumably at what is now the site of the Holloway College Electric Light Works, Mr. Whitaker[1] described an old pit, in which 'a thin layer of flint pebbles (and a few of quartz) was seen resting on the typical sands.'

About a mile to the SSE. and near the railway the pebble-bed again covers a sufficiently large area to be shown on the map. In it occurs the best section in the district, described by Mr. Hawkins[1] as follows:—'Three-quarters of a mile northwards (from Virginia Water Station), about 6 chains west of the railway and close to an "occupation" bridge, there is a pit showing 6 or 7 ft. of well-rounded dark flint pebbles overlain by a little sandy gravel. These pebbles seem to be at, or very near, the base of the Bagshot Beds, for there are several small springs close by, which are probably thrown out by the underlying London Clay.' In this pit the pebbles are scattered through the sand and do not form a shingle bank; the sand is markedly current-bedded, very felspathic, and in some layers slightly iron-cemented; thin layers of white pipe-clay occur, and there are a few clay-galls in the sand.

The pebbles are all flint, black externally and very well rounded; quartz pebbles occur sparingly, but none were found to exceed a quarter of an inch in diameter, and chert is absent.

Besides the section described by Mr. Hawkins there is now a higher exposure at the same locality, which shows the total thickness of the bed to be about 15 ft.

Further south, by Virginia Water Station, the railway cutting shows about 20 ft. of sands with a thin pebble-bed near the middle; but the horizon is apparently above that of the main pebble-bed, the debris of which is seen in the low ground beneath the Sanatorium. C. N. B.

A little to the west by the Clockhouse a fine section of the sands is seen, and at a farm immediately west of Virginia Water Station Mr. Hawkins recorded a section of the Bagshot pebble-beds, which is now hidden, but many pebbles lie on the surface of the fields and by the banks of the Bourne. There is a wide tract of these sands near Wentworth, but without sections. About a mile south of Barrowhills a deep pit showed the sands with pellets and seams of pipe-clay, one seam being a foot thick.

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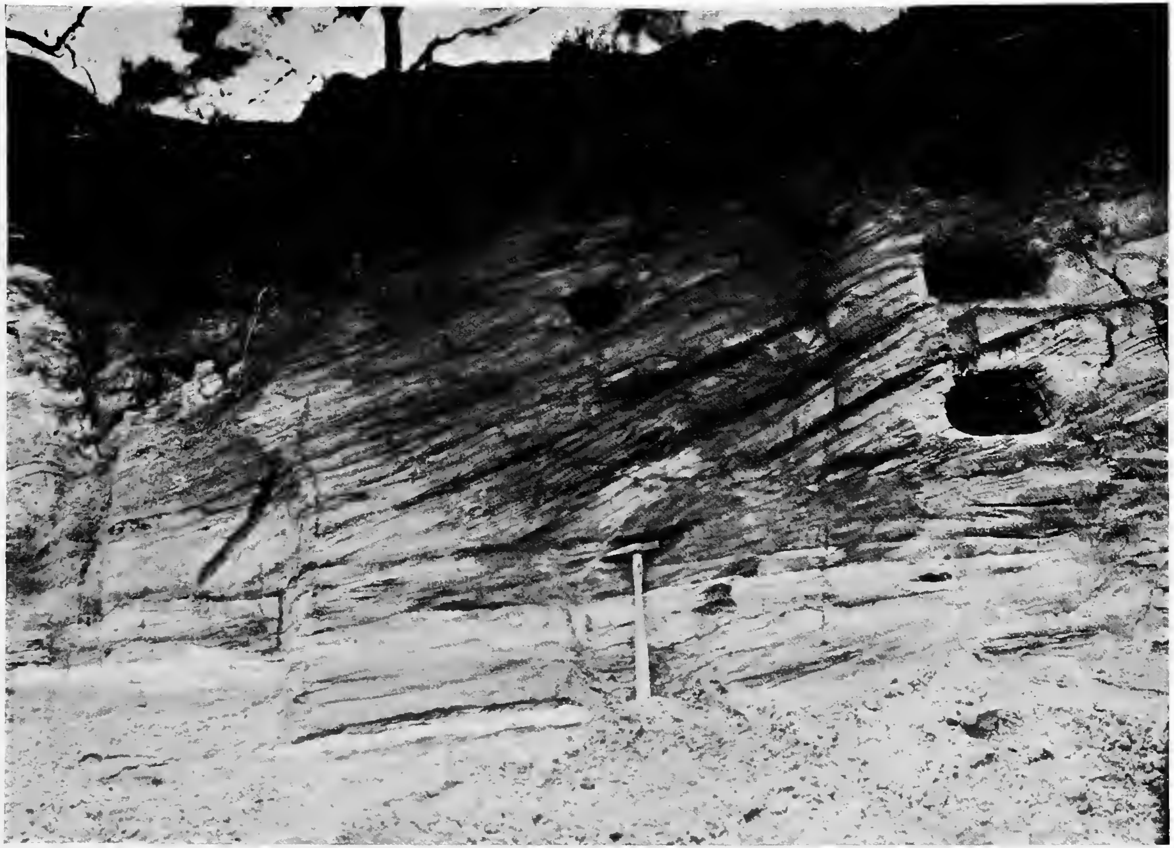
[1] *Mem. Geol. Surv.*, vol. iv, 1872, p. 315.



PIT IN WINDSOR PARK.
Current-bedded Bagshot Sand.

South of Barrowhills the normal sand is associated with the white powdery siliceous material already mentioned. A section of the fine material was exposed in a pit a few yards north of the church near Long Cross House, while another pit less than a quarter of a mile away showed sand of normal type.

A similar rapid change of texture occurs in the sands near Gracious Pond; one pit containing coarse sand with seams of pipe-clay up to a foot thick, while another near Butts Hill is in the fine material. The best instance of lateral variation of texture in a short distance is supplied at Brimshot; the polishing-powder factory shows the undermentioned section of fine sand, whereas a well a quarter of a mile east penetrated 37 ft. of coarse sand with some partings of fine sand.

In the pit at Burrowhill the following section was noted in 1911:—

	Ft.
Bracklesham Beds. A. Glauconitic sand, with flint pebbles B resting in eroded hollows in C	1½
Bagshot Beds. C. White sand, exceedingly fine grained, soft and velvety to the touch	15

There are many disused sandpits at Brimshot and Chobham in the normal sand, with thin partings of clay, but at Chobham Park a seam of clay some 2 ft. thick was worked for bricks.

The section at the polishing-powder factory at Burrowhill showed channels similar to that shown on Plate IV. in the fine sand infilled with glauconitic sand of Bracklesham age and a discontinuous bed of pebbles. H. D.

St. Ann's Hill.— Nearer to Chertsey the pebble-bed already described is reached in a pit situated at the foot of St. Ann's Hill at the point where the upper and lower roads to Chertsey diverge. The pebble-bed lies about 10 ft. below the level of the road, and is covered by about 25 ft. of the lower part of the sands. The overlying sands are unusually loamy and contain many fragments of lignite.

A little further east, between the upper and lower roads, is a second and larger pit, some 40 ft. in depth; the greater part of the section consists of white and yellow Bagshot sands, somewhat loamy, in which concretions resembling sarsen stones have been recorded.[1]

Towards the top is another pebble-bed, occasionally cemented into a conglomerate, from which Messrs. Monckton and Herries obtained indeterminable casts of univalve shells.[2] The pebble-bed succeeds naturally to the yellow sands; but it is overlain by some green and brown clays, which are certainly of Bracklesham age. These, however, do not naturally succeed the pebble-bed, but appear to have slipped down from the hill above.

As the map shows, St. Ann's Hill is an 'island' of Tertiary strata, completely surrounded by river deposits; there are several such islands to the south of Chertsey. An explanation of their origin is suggested below, p. 88.

Ottershaw.—Between Ottershaw and Botleys there are few sections, but temporary openings showed that the sands maintain their usual character.

About one mile east of Ottershaw Village are the Ongar Hill Brickyards. Here the Bagshot Beds have been exposed beneath the clays to a depth of about 8 ft. The sand is silvery white and very clean, and near the top contains, according to the workmen, a 'bed of great stones.' None of these were visible in place, but one, which we were assured had been extracted from beneath the clay, was a sarsen, and measured 4½ by 2½ by 2 ft. In addition, some patches of the sand were slightly cemented, as though the formation of sarsens had begun; thus confirming Mr. Herries's observation at St. Ann's Hill.

South of Ottershaw, just north of Dunford Bridge, there are several old pits on the west side of the Chertsey and Farnham road; one of these showed

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[1] W. H. Herries, *Geol. Mag.*, 1881, p. 173.

[2] *Quart. Journ. Geol. Soc.*, vol. xlii, 1886, p. 403.

30 ft. of current-bedded sand stained red towards the top. On the southern margin of the map, round New Zealand, the sands support extensive pine woods and have been dug for use on the golf links.

Addlestone.—Northwards the Bagshot Beds are exposed in the railway cutting between Addlestone and Addlestone Moor, and again in the Hatch brick-pits, just north of the railway, where they are overlain by Bracklesham Clays. The sands here contain little seams of peaty carbonaceous matter, and just below the junction with the Bracklesham Beds, impressions of leaves were noted. The pebble-bed which on St. Ann's Hill occurs at the top of the sands is represented by a few isolated flints, waterworn, but irregular in shape. The deepest section shows 5 ft. of the white sands, but as described below, the Bracklesham Clays lie in a basin cut in the sands, so that the thickness of Bagshot strata exposed in the various parts of the pit is about 20 ft.

East of the Wey.—East of the river Wey various exposures yield an almost complete section from the London Clay to the Bracklesham Beds.

The lower part of the Bagshot Beds is reached beneath a cover of river-gravel in the great railway cutting between Walton and Weybridge stations: the London Clay is seen at and east of Sir Richard's Bridge (the most easterly bridge over the line on the map), and owing to the slight dip, about 1°, towards the west, the higher beds come on successively in that direction. The section has been described in great detail by W. H. Hudleston,[1] whose results have been summarised by H. B. Woodward as follows[2]:—

		Ft.
'Valley gravel	... ...	about 20
Bagshot Beds.	5. Sand. Fine buff sand with clay-laminations	,, 12
	4. Loam. Buff sandy loams and sands, laminated, passing down into blue loam	12
	3. Sand. Red, yellow and white sands, with clay-laminations	7
	2. Clay. Dark blue laminated clay, becoming reddish-brown, with intercalated sand	4
	1. Sand. Yellow sand with clay-seam, ochrey layers, much false bedded	up to 6
London Clay.'		

Speaking of the relation of the Bagshot Sands to the London Clay, Hudleston wrote: 'The entire section is strongly suggestive of unconformity between the London Clay and the Lower Bagshots at this point.' (*Op. cit.*, p. 160.) The section is now obscured, but Hudleston's observation that 'the upper layers of the London Clay are on the whole more sandy than those of the base of the cutting,' and that clayey bands occur in the lower part of the Bagshot Sands, suggests the presence of the passage-beds which have been mapped in the area to the east under the name of Claygate Beds.[3]

At the western end of the cutting, by Weybridge Station, a section still open shows 25 ft. of typical Bagshot sands; these belong to the middle part of the division. This part is also well seen in the many sections made in connection with the Brooklands Motor Track, situated immediately south of the railway on the hillside overlooking the Wey.

At the north-west corner of Canes Wood, H. B. Woodward[4] noted the following details:—

	Ft.
'False-bedded ochreous sand, with irregular and impersistent clay-seams	about 20
Grey clayey sand with ochreous nodules	10
Pale clayey sand	5 to 10
Grey sand, ferruginous at base	15
Grey and brown sandy clay, throwing out springs.'	

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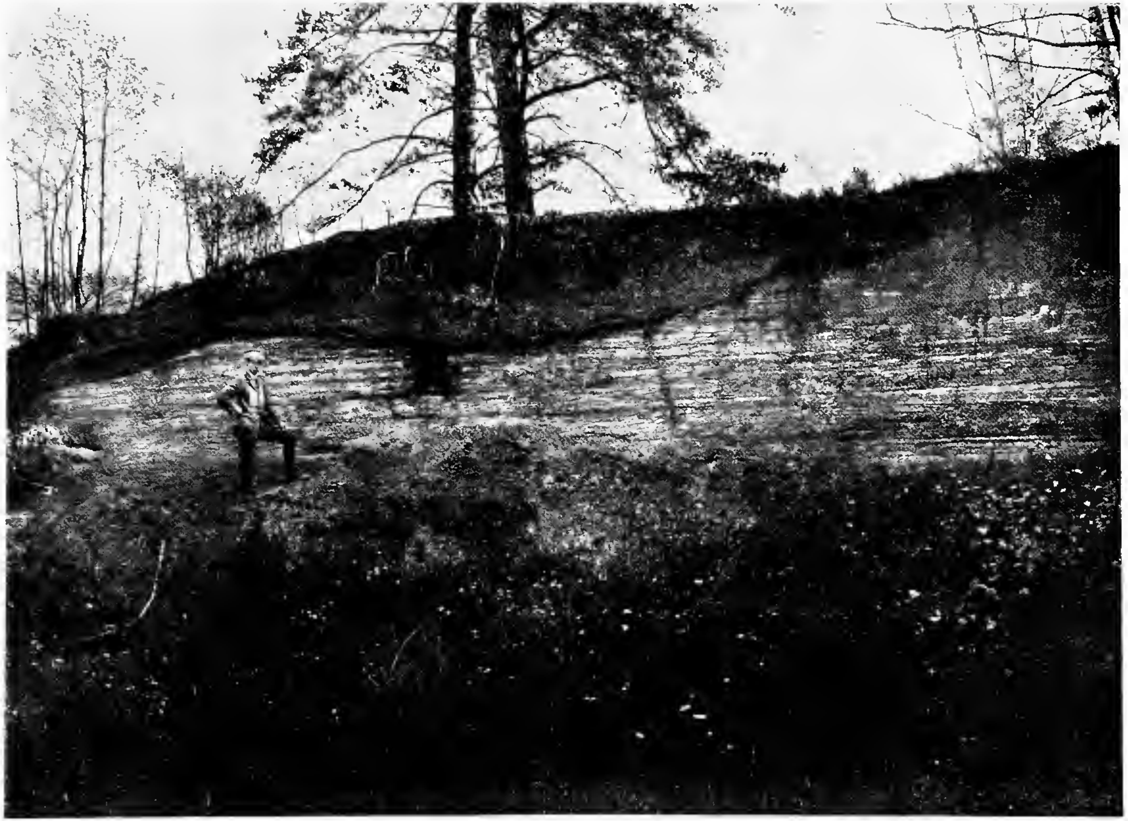
[1] *Quart. Journ. Geol. Soc.*, vol. xlii, 1886, pp. 147-172; vol. xliii, 1887, pp. 443-456.

[2] 'Geology of the London District.' *Mem. Geol. Surv.*, 1909, p. 40.

[3] 'Summary of Progress for 1911.' *Mem. Geol. Surv.*, 1912, p. 31.

[4] 'Geology of the London District.' *Mem. Geol. Surv.*, 1909, p. 41.



SAND-PIT AT ST. GEORGE'S HILL, WEYBRIDGE.
Junction of Bracklesham Clay and Bagshot Sand.

In 1911 a new section beside the railway showed 30 ft. of sands overlain by gravel in pockets, much contorted. Some bands of sand were much iron stained, while others were practically white; all were strongly current-bedded in themselves, but maintained fairly constant thicknesses, the partings being even lines, often with pipe-clay seams or lenticles, dipping about 8° to the south-east.

St. George's Hill.—The topmost beds of the Bagshot are well exposed on the flanks of St. George's Hill. At first sight they appear to be remarkably even-bedded, in regular layers some two inches in thickness, but on closer inspection it is seen that almost every individual layer is current-bedded. The best section is at the south side of the Fir Grove Brickyard, rather more than half a mile south-east of Weybridge Station (Plate IV.). About 15 ft. of Bagshot Sands are exposed, overlain at one side by Bracklesham Clays, which occupy a basin cut in the sand. The sands are mostly fine-grained and in parts brilliantly coloured; crimson, pink, orange, buff, lilac, grey, and white, occur in laminae or irregular streaks, and sand of all these tints can be collected from a small face.

Pipe-clay is abundant in bands up to half an inch in thickness and in little lenticles and pellets; it is white, grey, or deep crimson in colour. Ironstone occurs at the junction with the Bracklesham Beds as described below. The general aspect of the Bagshot Beds is seen in Plate IV., which shows the regular horizontal lamination, but the minute current-bedding of individual laminae is not distinguishable.

In this part of the wood the boundary between the clays and sands is marked by the growth of oaks and beeches on the one and firs and larches on the other; silver birches occur on both, but are more plentiful on the Bracklesham Series.

Current-bedded sands are also seen in the road-cutting near the south-eastern corner of Brooklands Motor Track, but the section is much obscured by slipping. On the south side of St. George's Hill, three furlongs east of Bridge Farm, there is a pit showing the junction of the Bracklesham and Bagshot Beds. Except for the absence of bright colouring the sands are similar to those described above. The colouring is, however, beautifully seen on the eastern slopes, notably in the little valley running from Hill Farm to the Mole, where there is a continuous section, some 4 ft. deep, in the banks of the ditch. There are also several small pits in Burhill Park where sand is dug for use on the golf links.

North of the Thames.—In 1835 a well was made at Littleton House, north-east of Chertsey. The account[1] shows that beneath 30 ft. of river deposits there is 12 ft. of blue clay and 40 ft. of blue sand before the London Clay is reached. The sandy beds were referred to the Bagshot Beds, but with doubt, since it was not considered probable that that Series occurred to the north of the Thames in this district. But the position of the site, in the axis of the London Basin syncline (see above, p. 18) lessens the improbability. The conclusion that they are Bagshot Beds is strengthened by the record of a later well at the same locality, giving the depth to the chalk as 570 ft. (*ibid.*) and also by the presence of passage-beds from the London Clay in the area north of Littleton and Laleham, mentioned above.

C. N. B.

Outliers.

Keep Hatch.—The most westerly outlier forms the small hill of Keep Hatch, where some 14 ft. of yellow sand with seams of pipe-clay are present. At the junction with the London Clay strong springs are given out, and are used at the farm. This outlier was not represented on the Old Series map.

Arthurstone.—A short distance to the east is the much larger outlier of Arthurstone. In it the junction of the Bagshot Sands and London Clay is clearly exposed near Beanoak Farm; the sand rests directly on the clay, the passage-beds (Claygate Beds) being absent. The banks about the high road are mostly overgrown, but the yellow sands, with pipe-clay seams, are exposed occasionally. In the railway cutting to the south the following section may be seen:—

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[1] 'Geology of London.' *Mem. Geol. Surv.*, vol. ii, 1889, pp. 130, 131.

		Ft.
Bagshot Beds.	Soil	1
	Dark sand	1
	Green grey clay	1 to 1½
	Grey sand	¼
	Pan	¼
	White and yellow sand and pipe-clay	3½
London Clay		3 +

The sand is sharp and clean, and is used for moulding sand by the London and South-Western Railway Company at their Eastleigh and Nine Elms foundries. The underlying London Clay forms a ledge along the cutting and throws out springs. At Amen Corner there are 5 ft. of current-bedded white sand with partings of pipe-clay, overlain by the relics of a pebble-bed. which also lie on the fields beside the main road. The section near Arthurstone recorded by Mr. Monckton is now overgrown.

Easthampstead.—There are several small outliers in Easthampstead Park, the most important being at the Hall and Home Park Farm.

The basal pebble-bed was dug formerly at Wickhill, Bracknell, and in 1910 was exposed, beneath 10 ft. of sand and gravel, in the grounds of Holly Spring.

Windsor Great Park.—The most northerly extension of the Bagshot Beds is the outlier south of St. Leonard's, on the north-west side of the Windsor and Ascot road. The sands were formerly dug, and in one pit near the centre of the outlier traces of the pebble-bed were noticed. There is also a small outlier by Cranbourne Tower, and several other little patches in Windsor Park; a rather larger one at Buckhurst Park, on the southern margin of the Park, shows 20 ft. of white sand. H. D.

BRACKLESHAM BEDS.

Introduction.—The Bracklesham Beds form a well-marked lithological division. They were first described by Warburton,[1] who pointed out that they consist of an upper and lower clay-series separated by glauconitic sands. These divisions were accepted by Prestwich[2] in his paper on ' The Structure and Age of the Bagshot Sands.'

In this paper he correlates this sub-division of the original Bagshot Series with the Bracklesham Beds of the Hampshire Basin. By comparing the fossils from each area he showed that five species are common to the beds in both areas which are in the Hampshire basin distinctive of the Bracklesham Beds (*op. cit.*, p. 398).

Prestwich's classification was adopted with a slight modification by the Geological Survey[3] in the Old Series Map, Sheet 8. the lowest beds of his Upper Bagshot (now Barton) Series being included in the Bracklesham or ' Middle Bagshot ' division.

Dr. Irving[4] in 1885 returned more nearly to Prestwich's grouping, but he further sub-divided the series into seven beds, the distribution of which he indicated over an area including Crowthorne, Ascot and Bagshot.

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[1] *Trans. Geol. Soc.*, series II, vol. i, 1824, pp. 48-52.
[2] *Quart. Journ. Geol. Soc.*, vol. iii, 1847, p. 383.
[3] *Mem. Geol. Surv.*, vol. iv, p. 330.
[4] *Quart. Journ. Geol. Soc.*, vol. xli, p. 492.

These minor divisions were based on the results obtained in sinking a well at Wellington College, and as frequent reference will be made to Dr. Irving's work, his published section is here summarised.[1]

Wellington College Well.

			Ft.
UPPER BAGSHOT [BARTON].	Nos.	1, 2.—Upper sands	22
MIDDLE BAGSHOT [BRACKLESHAM]	,,	3.—Flint pebbles...	1
	,,	4, 5.—Sand, loam and clay	15
	,,	6.—Pebble-bed	3
	,,	7, 8.—Green sand, lower part dark green	38
	,,	9, 10.—Clay, darker and carbonaceous below	20
LOWER BAGSHOT	,,	11, 12.—Sands, slightly varying in character	92

Lithological characters.—The lowest member of the Bracklesham Beds in this area consists of loams and clays well adapted for brick-making, and therefore exposed in a number of pits. In colour they vary from lilac and purple to brown or yellow and red. They are usually laminated and evenly bedded, though one or two sections show fine current-bedding. With the exception of lignite, no fossils have been found in them. Pyrites occurs in nodules, and there are sometimes little pockets of glauconitic sand. Dr. Irving distinguishes two beds belonging to this division (Nos. 9 and 10), but these have not proved traceable in the field. A feature of the lower division of the Bracklesham Beds is its tendency to occur in eroded hollows or channels cut in the Bagshot Sands. Where these are moderately deep one or more bands of ferruginous material are often developed at or close to the junction of the two, and in some cases this material becomes an ironstone of sufficient purity to be worked. The best illustration of this phenomenon occurs at St. George's Hill, in the south-eastern part of the area. The middle member contains Dr. Irving's divisions Nos. 7 and 8, and consists mostly of green sands with occasional clay-bands in which casts of fossils are found locally. The beds are characterised by the large amount of glauconite they contain.

The upper member (Nos. 4 and 5 of Dr. Irving's series), consists of drab coloured, buff and yellow clays and sandy loams, occasionally laminated. Separating these beds from the glauconitic division, there is sometimes present a bed of well rolled flint pebbles (No. 6 of Dr. Irving's series).

The lenticular character both of the finer deposits and of the pebble-beds makes it difficult if not impossible to trace the three members in the field. Apart from the excavations for brick-making sections are rare; across wide stretches of pine-wood and open common there are often none; and owing to oxidation the distinctive green tint of the glauconitic sands is lost. The most serious difficulty, however, is the surface drifting of these fine deposits, which has resulted in much of the ground being covered to some depth by fine sand not really in place. The area actually occupied by the sands has been much widened by downwash during heavy rains, the soil thus supplied being often thick enough to support pine-growth where the stratum *in situ* is really clay. On the other hand, the presence of the clay itself can not be inferred from the occurrence of marshy ground, for a water-tight 'pan' often forms at a depth of some 2 ft. down in the sand, and gives rise to water-logged ground.

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[1] 'Bagshot Beds of Bagshot Heath.' 1892. *Privately printed.*

Palaeontological features.—The glauconitic beds of the Middle Bracklesham have locally yielded many fossils, mostly casts of shells, and fish teeth. The chief localities are the railway cutting[1] between Bagshot and Ascot, Chobham Place and Oystershell Hill; while from Goldsworthy Hill and Shapley, a little south of this area, Prof. Prestwich obtained a large number of fossils, including fish teeth and some bones of turtles.

These organic remains all point to deposition in a comparatively shallow sea under a warm climate. The deposits seem to indicate a sea-margin liable to varying conditions. The pebble-beds are of the nature of shingle-banks and show current-bedding, whereas the glauconite[2] was probably formed below the level at which wave-action makes itself felt.

Soil.—The soil produced by these beds is usually fertile, but the clayey series sometimes give rise to peaty swamps, as for instance at Owlsmoor and on parts of Chobham Common. Elsewhere, especially around Virginia Water, it supports fine deciduous trees, forming a strong contrast with the pine-woods of the Bagshot and Barton Sands.

Thickness.—The Bracklesham Beds vary much in thickness, the variation being partly due to lenticular bedding and to the irregular manner in which the lowest member has been deposited in hollows of the Bagshot Sands. In this way great local variations of thickness may be brought about, but besides these, on taking the average over fairly large areas, there is found to be a notable attenuation towards the north. Round Wellington College and Crowthorne the total thickness of the Bracklesham Beds may be as much as 80 ft., and on St. George's Hill 100 ft., whereas at Chavey Down and Ascot there can not be more than 30 ft.

Extent.—The main outcrop of the Bracklesham Beds forms an irregular belt or fringe to the great tract of Barton Beds in the south-western part of the map, expanding eastward around the small outlier of the same beds on Chobham Common. To the north and east of the main outcrop there are several outliers of the Bracklesham Beds crowning the hills about Chavey Down, Ascot and Sunningdale, and to the east capping the high ground of Callow, St. Ann's and St. George's Hill, overlooking the valley of the Thames.

H. D.; C. N. B.

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[1] Monckton, H. W. *Quart. Journ. Geol. Soc.*, vol. xxxix, 1883, p. 349.

[2] Clarke, F. W. 'Data of Geochemistry.' 2nd edition (*U.S. Geol. Surv. Bull.* 491), pp. 124 and 492; also Murray and Renard, *Challenger Report*, 'Deep-sea Deposits.' p. 383, 1891.

LOCAL DETAILS.

Main Outcrop, North Side.

Commencing at the western edge of the map we find that the sections of the Bracklesham Beds in the railway cuttings north of Wellington College are now obscured, but these, when fresh, were examined by Mr. Monckton[1] and by Dr. Irving,[2] who differed, however, in their interpretation of them.

While examining the area for the survey, Mr. J. H. Blake noted a small section near the Devil's Highway showing 7½ ft. of liver-coloured clay and brown sand; while diggings in the woods close by were mostly in grey plastic clay mixed in places with brown clay.

Dr. Irving[3] has published an account of two wells sunk in this neighbourhood; the first at the Wellington Hotel passed through the beds Nos. 3 to 7 of his type section; the second, at Holloway's Brick Kiln, passed through beds Nos. 9 to 11 of the same section.

During the recent survey some sections were observed in the banks of the small brook which flows from the College Lakes, these show the following beds:—

	Ft.
Current-bedded red sand with fossils, blue clay and pebbles ...	4
Yellow clay	2+

A few yards to the north of this exposure the same beds were dug for brick-making. A similar clay, associated with green sand and pebbles, is exposed in a ditch on the golf links.

A well at a new house between the links and the Wokingham Road passed through green sand into 18 ft. of greenish clay. Green sand is also exposed in Ellis Road and again in the Crowthorne Brick Works, situated on the east side of the Wokingham Road just south of Bigshotte Rayles. In 1910 the working face here showed the following section:—

	Ft.
Red loam with phacoids of green sand	5
Green sand	5
Lilac clay	4
Glauconitic sand	4
Olive-green clay; iron stained water given out 4 ft. from base of pit	10

The beds dip gently south, so that the lower clays rise to the surface further north and were encountered when the footings for Bigshotte Rayles were excavated. The lower clays were worked at an old brick-yard by the cross-roads south-east of Pinewoods Sanatorium. The section has been described and figured by Dr. Irving.[4]

Between this locality and Caesar's Camp, sections are rare, the ground being mostly swampy heathland, intersected by a few small streams. But one of these, rising near Round Hill, Crowthorne, lays open the whole sequence. Commencing near the Bracknell Road the pebble-bed (No. 3) at the base of the Barton Sands is exposed and can be traced into the adjacent field. It overlies the upper clays, which are in turn succeeded by the glauconitic sands. The lower clays are exposed near a small pond into which the stream flows, and they can be followed from this point to the old clay-pit already described at Pinewoods. Dr. Irving dug a series of pits at Clay Hill to prove the nature and thickness of the Bracklesham Beds; the results obtained accord with the succession seen in the small stream just described. The total thickness did not exceed 40 ft.

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[1] Monckton, H. W. *Quart. Journ. Geol. Soc.*, vol. xxxix, 1883, p. 351; also Monckton, H. W., and R. S. Herries. *Quart. Journ. Geol. Soc.*, vol. xlii, 1886, p. 407.

[2] Irving, A. *Proc. Geol. Assoc.*, vol. viii, 1883, p. 150; also *Quart. Journ. Geol. Soc.*, vol. xli, 1885, p. 498; and *ibid* vol. xliii, 1887, p. 388.

[3] 'Recent contributions to the Stratigraphy of the later Eocenes of the London Basin, Wellington College,' pub. privately, 1891, pp. 14 and 15.

[4] *Science Gossip* for May, June, 1891.

South Hill Park.—The lower clays are exposed near the New Pond, north-west of Caesar's Camp, and were worked in a field on the west of South Hill Park for making the bricks with which the hall is built. In the kitchen garden the glauconitic sands are 14 ft. below the surface, but the clays and glauconitic sands are exposed in the northerly spur by the east lodge of the park, while further north the lower clays are seen beside the main road.

The deep ditches alongside the rides traversing the woods between South Hill Park and Swinley Forest frequently show sections of the Bracklesham Beds; the best are along Parson's Ride and Red Lodge Ride. The latter has been described by Dr. Irving[1] as follows:—

3.—Pebble-bed *in situ*, seen in ditch near the corner of South Hill Park (300 ft. O.D.).
4 and 5.—Loam and stiff clay, passing down into green earthy sand.
6.—Pebble-bed.
7 and 8.—Green earthy sands and loams.
9 and 10.—Clay and loamy ferruginous sand.
11.—Fine quartz sand.

Nos. 7 and 8 apparently thin out entirely in the hill, on the north flank of which (N.E. of South Hill Park) only the clays appear to crop out.

Swinley Park.—Worldsend Hill consists mainly of clay, the glauconitic sands having presumably thinned out. At Blacksmith's Hill, west of Passmore's Cottages, a deep sand-pit shows the following section:—

		Ft.
	Soil	1½
Bracklesham Beds.	Green sandy clay	1
	Rounded flint pebbles in green and drab clay ...	1
	Yellow and crimson sand	2
Bagshot Sands.	Current-bedded, white, lemon and yellow sands, iron cemented layers and concretions, traces of grey pipe-clay	8

The thickness of the Bracklesham Beds in South Hill Park is between 40 and 50 ft.; in Swinley Forest it is quite 50 ft.

Half a mile to the south the upper clays are worked on both sides of Bagshot Road for the manufacture of Lawrence's 'rubber bricks.' The section in the pit on the west of the road was:—

	Ft.
Soil	2
Grey clay with veins and pockets of very fine-grained white sand	6
Glauconitic sand with casts of *Turritella* and *Venericardia* ...	6

On the eastern side of the road the present working face of the pit is in grey and yellow loam; but in the southern face glauconitic sand rests on dark-grey clay.

Dr. Irving[1] thus described these sections:—

Mr. T. Lawrence's Brick-field, Swinley.

Upper Sands (Barton) of Tower Hill (about 60 ft.) with a good fresh exposure of 20 ft. in a new sand-pit (base 300 ft. O.D.).
4 and 5.—Loamy clay . . . passing down in a strong laminated clay.
6 to 8.—Dark-green earthy sand, full of flint pebbles at the top: proved beneath [4 and 5] in trial holes, and cropping out at the north end of the brickfield.
9 and 10.—Mixed clay and sand bed, exposed in a pit close to the tramway (base about 260 ft. O.D.).
11 and 12.—Fine quartz sand in the valley.

About half a mile further east and close to the Ascot and Aldershot branch of the London and South-Western Railway, there was a brick-pit, now overgrown, known as Hagthorn Hill Brickyard. Descriptions of this pit have been published by Mr. Monckton[2] and by Dr. Irving.[3] Their differing accounts illustrate the variation in minor details of the Bracklesham Beds. The thickness of the Bracklesham Beds near this pit may be estimated at 46 ft., for the basal pebble-bed of the Barton occurs on top of the hill south of Kingsride at 300 ft. O.D., and the base of the Bracklesham Beds near by at 254 ft. O.D.

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[1] *Quart. Journ. Geol. Soc.*, vol. xliv, 1888, p. 165.
[2] *Quart. Journ. Geol. Soc.*, vol. xlviii, 1892, pp. 49, 50.
[3] *Ibid.*, vol. xliv, 1888, p. 166.

The beds formerly exposed in the cutting on the South-Western Railway north of Earlywood are described by Mr. Monckton[1] as follows:—

		Ft.	in.
1.	Fine light-yellow sand		
2.	Yellow sand, with layers of darker-coloured iron-sand ...	2	6
3.	Pebble-bed, with rolled flint pebbles in iron-sand matrix often greenish	0	10
4.	Yellow sand, with layers of iron-sand, passing into a finely laminated sandy clay, with patches of yellow and greenish sand ... ... about	10	0
5.	Layer of flint pebbles	0	2
6.	Yellow and liver-coloured foliated sandy clay	3	0
7.	Green sand, with a little dark clay, casts of shells abundant in a layer of yellowish sand	8 or 9	0
	Fusus longaevus, Lam.; *Fusus*, ?*sp.*; *Voluta*, ?*sp.*, like *V. cithara*, Lam.; *Pleurotoma*, ? *sp.*; *Natica sp.*; *Turritella sulcifera*, Lam.; *Phorus agglutinans*, Lam.; *Ostrea flabellulum*, Lam.; *Pecten corneus*, Lam.; *Cardita carinata*, ? Sow.; *C. planicosta*, Lam.; *Cardium porulosum*, Brand.; *Protocardium semistriatum*, Desh.; *Cytherea nitidula*, Lam.; *C. suberycinoides*, Desh.; *Corbula gallica*, Lam.; *C. striata*, Desh.; *Gastrochaena corallium*, Sow.; *Serpula sp.*; and wood.		
8.	Clays.		

In a new road near Ascot Convent, the glauconitic sands and lower clays were exposed; they are also seen near Bery Stede, overlying the Bagshot Beds. Further south the lower clays may be seen near Earlywood Lodge, the glauconitic sands occurring a little to the north, specially well seen near Broadlands.

Sunninghill.—The Bracklesham Beds are well developed at Sunninghill. In Silwood Park, south of the mansion, blue clay was proved in a well to a depth of 17 ft. and in Sunningdale Park thick beds of clay support the fine forest trees. The bricks used in building the house were made at a kiln near the road bounding the Park on the south. The clays are lilac in colour and resemble the Lower Beds of the Bracklesham Series, and, moreover, are overlain by green glauconitic sand which is exposed in some deep gravel-pits at the top of the hill west of the house.

To the south of Sunninghill they were exposed when the railway was made, but the sections are now mostly obscured. In the most westerly section some seams of white clay about 2 ft. thick, occasionally interbedded with yellow and orange loam, overlie the Bagshot Beds, but there is some doubt as to which division the clays belong. In the cutting opposite the gasworks there is a bed of strong clay; further east the sections are obscured, but that described by Dr. Irving is still partly open. Dr. Irving's[2] description is as follows:—

CUTTING ON THE SOUTH-WESTERN RAILWAY, HALFWAY BETWEEN ASCOT AND SUNNINGDALE STATIONS.

	Ft.
Clay (= No. 5)	5
Glauconitic green earths (Nos. 7 and 8)	14
Strongly laminated light purplish and grey clay (= No. 9) ...	6
(No. 10 apparently wanting)	
White and yellow fine quartz sand (No. 11) exposed to the level of the line	4

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[1] *Quart. Journ. Geol. Soc.*, vol. xxxix, 1883, p. 349.

[2] *Quart. Journ. Geol. Soc.*, vol. xliv, 1888, p. 166.

A portion of this section, still exposed, shows the following beds:—

	Ft.
Surface soil	
Green and yellow sand	5
Yellow loam with pockets of glauconite	
Glauconitic sand	14
Lilac clay	6

To the south of the railway the glauconitic sands are exposed in the stream banks near Charters and the upper clays near King's Beeches.

To the south-east of Sunningdale Station the Bracklesham Beds form a well-marked escarpment. In an old brickyard at Titlark's Farm 3 ft. of lilac clay overlain by 10 ft. of glauconitic sand with casts of *Corbula* and *Turritella* are still exposed. These beds are at the base of the escarpment and are overlain by clays and sands, and these by a thick bed of pebbles (No. 3) which covers much of the surface of the Golf Links and is dug in many deep pits. East of the Dormy House the lilac clay is replaced locally by some 8 ft. of white pipe-clay. The beds are traceable thence across the north of Chobham Common, the glauconitic sands and clays capping the long ridges by Ship Hill (Little and Long Arm). They are also seen in section beside the Victoria Memorial, indicated on the map by the word 'Cross.' Poorly preserved casts of fossils are numerous in the glauconitic sands in a deep road-cutting north of Staple Hill. This locality was described by Prestwich,[1] who was able to determine the commonest species, from a specimen which had retained traces of its shell, as *Venericardia planicosta.*

On account of the abundance of the fossils the hill is known locally as Oystershell Hill. Similar casts of *Venericardia* are common in a field near the railway cutting north of Barrowhills, where they occur in association with *Corbula.*

Main Outcrop. South Side.

Sandhurst Lodge.—Beginning at the western edge of the southern outcrop, the exposures of the Bracklesham Beds are poor, but the green sands were recognised in a cutting in a lane near Sandhurst Lodge. At Ambarrow Hill, quarter of a mile east of Sandhurst Lodge, a section laid open when the railway was made has been described by Mr. Monckton[2] as follows:—

	Thickness.
'Gravel.	
Light yellow sand, with small patches of green sand, casts of shells, numerous but very imperfect, including species of *Fusus*, *Natica*, *Phorus*, *Turritella*, *Voluta*, wood, etc.	50 ft. or more.
A greenish sand, with two irregular lines of flint pebbles, and a few pebbles of old rock	1 ft. 6 in.
Yellowish sand, iron-sand concretions, and layers, a few casts of *Turritella*, and wood	2 to 4 ft.
Yellowish, reddish or greenish sand, with numerous thin laminae of light-coloured clay	About 15 ft.
[This bed was, until recently, worked for bricks at Wellington College.]	
Dark coloured laminated clay, with an irregular line of flint pebbles; green sand	Not shown.
Dark laminated clay, with a little impure green sand. (This bed is shown in a pit at Upwick or Wick Hill near Finchampstead.)'	

An account of a well at Ambarrow House, about 100 yards west of the railway, has been published by Dr. Irving and is referred to on page 99. A comparison of these two sections again shows the variability of the beds in a short distance.

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[1] *Quart. Journ. Geol. Soc.*, vol. iii, 1847, p. 389.

[2] *Quart. Journ. Geol. Soc.*, vol. xxxix, 1883, pp. 350-351.

The pebble-bed described by Mr. Monckton in the account quoted above is still visible in the railway cutting near by, with some yellow sand resting on it; this bed is apparently at the base of the Barton Sands.

An old brickyard south of Wellington College still shows a section of poor loamy sand, and remnants of a pebble-bed lie on the fields of the sewage-farm.

In the swampy valley at Owlsmoor, building operations have exposed the upper clays and the glauconitic sands. To the south-east, at Barossa, the green loams appear in a deep trench on the golf links, and at one point a bed of pebbles.

Bagshot.—North of Bagshot Station the cutting shows the grey clays of the Bracklesham Beds overlain by the Barton Sands and Pleistocene Gravels. Near Bagshot Green an ornamental lake occupies an old brick-pit in the upper clays. In the woods north of Bagshot Park a pebble-bed occurs a few feet below the Barton Beds and may represent the bed so frequently found at that horizon. It is underlain by clay, which was worked for bricks when the palace at Bagshot was being built, and which supports the fine forest trees in the Duke of Connaught's Park and Queen's Wood. At the head of the Windle Valley, a section at Rapley Farm shows yellow laminated clay, veined with green sand, underlying a bed, about a foot thick, composed of smooth black flints, this being covered by about 3 ft. of loam. Similar yellow and green loams hold up the water in the neighbouring lakes and fish-ponds, and are exposed at times in drainage-trenches through the woods. The Upper Clays and glauconitic sands were cut open in making the golf links at Duke's Hill, and are exposed beside the Bracknell road.

Windlesham.—On the north side of the valley of the Windle Brook sections are rare between Bagshot and Windlesham, the ground being largely occupied by nursery plantations. To the south of Windlesham the upper clays form the arable land near Broadway Green Farm, and the underlying sands crop out in the farmyard. A few sections which occur east of Windlesham have been described by Prestwich, Herries, and others. During the survey a clay-pit was seen near Westwood Lodge showing 5 ft. of the upper clay, varying in tint from yellow to greenish-blue, resting on glauconitic sands. In the grounds of Windlesham Court there are several disused pits in the same bed of clay, which throws out springs where it underlies the Barton Sands. It was dug at Ribsden, and further east gives rise to a marsh though the clay itself is covered by a downwash of sand from the Barton Beds.

The foundations of a gas-holder in Hyams Lane showed fossiliferous glauconitic sand and lilac clay; it was from a trench close by that Mr. Herries found a number of fossils.[1]

South of Chobham Place the road-cuttings have yielded more fossils from the Bracklesham Beds than any other locality in the London Basin; lists of these have been given by Prestwich and by Herries. All occur as casts, mostly external, but a few are internal. A small proportion only are identifiable, and of these, Prof. Prestwich gives the following list[2] :—

Cardium semistriatum ?, *Desh.*	Chobham Place.
Corbula gallica, *Lam.*	Chobham Place.
Nummulites laevigatus, *Sow.*	Chobham Place.
Ostrea flabellula, *Lam.*	Chobham Place and Windlesham.
Venericardia elegans, *Desh.*	Chobham Place and Windlesham.
Venericardia planicosta, *Lam.*	Heath north of Chobham.

The sections are now obscure, but several feet of glauconitic sand are still visible and casts of fossils are met with occasionally. The hill slopes eastwards to Home Park, the lower lilac clays being exposed in the roadside, overlying Bagshot Sand. East of Chobham Place, at Clearmount, are glauconitic sands, while vestiges of a pebble-bed are found on the common to the north. The basement clays give rise to the dreary swamp, Albury Bottom, while the glauconitic sands and overlying clays form an escarpment which flanks it on the west and north.

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[1] *Geol. Mag.*, 1881, p. 174.

[2] *Quart. Journ. Geol. Soc.*, vol. iii, 1847, pp. 389 and 390.

Outliers North of Main Outcrop.

Of the outliers on the north of the main outcrop, those in the neighbourhood of Ascot were first described by Dr. Irving, while the most westerly at Bill Hill, Bracknell, was noted by Messrs. Whitaker and Monckton.

Bill Hill.—This remnant of the Bracklesham Beds is exposed in a sandpit near the top of the hill, showing yellow and reddish loamy sands penetrated by spiral tubules of glauconitic sand.

Chavey Down.—In the larger outlier occurring at this locality, the road ditches at Long Hill, opposite Martin's Heron, show that the whole sequence of the Bracklesham Beds is present, though reduced in thickness. As described by Dr. Irving,[1] at the foot of the hill the lower clays are often well seen; higher up, the glauconitic sands, much diminished in thickness, come on, while the upper clays are present near Chavey Down village. At Chavey Down, just above the 300-ft. contour, the base of the series, merely a foot of red clay, rests upon the Bagshot Sands; while the clay and glauconitic sands were worked at Goater's Hill in a pit described by Mr. Monckton.[2]

Ascot.—At Ascot Heath another large outlier is for the most part covered with plateau sand and gravel. In Ascot Churchyard the Bracklesham clays are at the surface, but the glauconitic sands are met with in deep graves. The clays are also seen near Englemere House, and a cutting behind the stables showed 10 ft. of green clay and sand. The beds were exposed when a house and Japanese garden were made near the road leading to the station. A pit on the racecourse shows 4 ft. of loam and sand (Bracklesham) resting on Bagshot Sand with concretions of oxide of iron.

Sunningdale.—The outlier east of Sunningdale and south of Virginia Water is remarkable for the beauty of the forest trees which grow on the clay beds. The lower clays are present in Coworth Park and form the subsoil of the famous Cedar Drive leading to Virginia Water. They are also present at Portnall Park, where they were once worked for brick-making. One of the pits near the Home Farm still shows several feet of drab clay. The middle (glauconitic) sands are seen in some disused gravel pits near Belvidere Fort, and were recently laid open in making a new road to the fort. The sands are 4 ft. thick here, and rest upon the drab clay, the whole being covered by gravel.

Near Broomfield Hall the clay was worked for bricks and was also exposed in the foundations of a new house at Shrub's Hill for a depth of 5 ft. with 10 ft. of white current-bedded sand below.

Knowlehill.—There are three small outliers of the Bracklesham Beds, near the South-Western Railway, in all of which the glauconitic sands have been met with. It was from these sands, nearest to Knowlehill, that Prof. Prestwich obtained casts of *Venericardia*. During the recent survey casts of both this fossil and *Corbula* were found in a field on the south side of the railway cutting.

Callowhill.—Some two miles further north, on the west side of the railway is the outlier of Callowhill.

Outliers South of the Main Outcrop.

Chobham.—Of the two small outliers to the south of Clearmount, the more southerly, near Brimshot, consists of glauconitic sand; in the other some clay is present. Both the beds rest in hollows eroded in a powdery fine sand of Bagshot age (see p. 33).

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[1] *Quart. Journ. Geol. Soc.*, vol. xliv, 1888, p. 170.

[2] *Ibid* vol. xlviii, 1892, p. 55.

Outliers East of the Main Outcrop.

Childown and Ottershaw.—Immediately east of the main outcrop is the large outlier, almost severed in the middle, on the north part of which Childown Hall is situated, and on the south, part of Ottershaw Park. In the Childown area the characteristic clays and sands are seen at Flutters Hill, and a well (see p. 114) passed through 40 ft. of these beds; at and near the Homestead, pits have been excavated in the clays which in the farmyard are covered by about 7 ft. of green sand. At Childown the lower clays were burnt for bricks.

H. D.

Traces of a pebble-bed are seen on the south side of the main road at Fan Court, but it is better exposed in the closely adjacent small outlier of Hersham Farm; here an old pit shows the pebble-bed at the top of the glauconitic sands.

Just north of the house, at Fox Hills, a few feet of the upper coloured clays overlie white sand. The grey and lilac clays, near the base of the division, are exposed in an old pit close to the road on the west side of Botley's Park.

In the Ottershaw area, the two small hills in the grounds of Queenwood are capped by the pebble-bed (as shown on the map); several small gravel-pits were opened in it. The well at the house is 40 ft. deep and probably just touched the Bagshot Sands. On the west side of Stanner's Hill the total thickness of the Bracklesham cannot be more than 30 ft., the Barton pebble-bed at the top and the Bagshot Sands at the base being only a short distance apart.

At Ottershaw Park a deep boring was made, a brief account of which has already been published.[1] When visiting this locality Mr. Reid noted a temporary section in the new drive close by, which showed:—

	Ft.
Green loamy sand	15
Light brown laminated and contorted clays	7
Black clay and lignite	3

The clays belong to the top of the lower division of the Bracklesham Beds, and the boring started 25 ft. lower down in this division.

In the account published in the 'Summary of Progress for 1910' it was considered that the base of the Bracklesham Beds was reached at a depth of 89 ft., making a thickness of 114 ft. in all for that division. Observations made on the surrounding ground since the date mentioned indicate that the base might have been expected at a depth of about 40 ft., and though the clays are known to lie in eroded hollows in the Bagshot Beds, no instance is known of their attaining a thickness of over 100 ft. The boring was made by drill-rods, and it is possible that clay worked down the hole, and led to the base being placed too low.

Brox.—To the east of Ottershaw Park is the smaller outlier on which the village of Brox is situated. There are no good sections; the clay being visible only in ditches, and the sands in the hillside east of the church. The pebble-bed in the Bracklesham Beds occurs as an outlier on a small knoll in the park, just behind the school. The outlier represented on the map round the church is formed by the pebble-bed which lies at the base of the Barton Sands.

Row Hill.—Further east is the outlier of Row Hill, in which the lower clays are well represented and have been extensively worked for brick-making. The only pit now worked is at Ongar Hill, where at one point 30 ft. of more or less laminated, greyish-lilac clay is exposed. The clay is separated from the underlying Bagshot Sand by a bed of ironstone nodules.

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[1] 'Summary of Progress for 1910.' *Mem. Geol. Surv.*, 1911, p. 25. See also p. 112 of the present Memoir.

The clays contain many irregular lumps of pyrites but no selenite. At the time of the recent survey the south face of the pit showed:—

	Ft.
Contorted clays, sands and gravel	4—6
Grey and yellow sand	0—3
Laminated lilac clays	10

The contortion visible in the highest beds is a common feature here; the admixture of clay, sands and gravel is not due to original deposition, but seems to have resulted from mechanical force (see p. 81).

Chertsey Area.—In the neighbourhood of Chertsey there are two outliers of Bracklesham Beds. That of St. Ann's Hill, about a mile north-west of the town, has been much affected by landslipping. The basal lilac clays are still visible in an old pit, now known as the Dingle; they are succeeded by the glauconitic sands, the thickness of which is doubtful, but the two together seem to have a thickness of about 30 ft. Above the sands and capping the hill is a pebble-bed of the normal type, consisting of well-rounded black flint-pebbles in a matrix of sand; and on this rests a thin sprinkling of Plateau gravel. Judging from the thickness of the underlying beds and the absence of the upper clays we take this pebble-bed to be the one in the Bracklesham Beds. It has, however, been taken to be the Barton Pebble-bed by Messrs. Gardner, Keeping and Monckton,[1] who refer to the occurrence of fossils in it, which could not be identified.

To the south-east of Chertsey is the outlier of Woburn Hill, in which the well-known Hatch Brickyards are situated. The clays here worked were regarded by Hudleston[2] as a clayey facies of the Bagshot Beds. His opinion was based mainly on the fact that they lie at a lower level than the Bracklesham Clays of St. George's and Ongar Hills on either side. But there is reason to believe that they lie in a syncline, and further it is clear that they occupy one of the many hollows eroded in the Bagshot Beds to which reference has been made. Captain H. G. Lyons[3] has discussed the question in detail, and his conclusions have been confirmed during the recent survey. The sides of the eroded hollow show a maximum slope of about 12°, and they clearly transgress the bedding of the underlying sands. The bedding in the Bracklesham Beds is approximately parallel to the sides. The basin is lined with a hard ironstone pan varying from 3 to 8 ins. in thickness and similar to the pan occurring in a corresponding position all over the outlier of St. George's Hill, to be described presently. At the last named locality Hudleston recognises the beds immediately above the pan as being of Bracklesham age.

The following section was seen in 1911 in the central part of the pit:—

		Ft.
Bracklesham Beds.	Lilac and brown laminated brick-earth, strongly current-bedded, planes dipping south-east	about 6
	Horizontally-bedded sands, thinning towards south-east to a horizontal parting ...	0—1
	Brick-earth, similar to above, bedding planes dipping north-west	6
	Thin iron parting	
	Pale lilac loam, very dense	1—1½
	Ironstone	½—1
White Bagshot Sand		5

St. George's Hill.—In the most easterly outlier, that of St. George's Hill, much downwash has accumulated at the foot of the slopes, about the junction of the Bracklesham Beds and the Bagshot Sands. This is especially the case on the north-east side of the hill, but some temporary sections seen in 1913 made it possible to trace the boundary with some approach to accuracy. In other parts of the hill the boundary can often be fixed by aid of the old workings (long trenches) in the ironstone or iron-pan, already referred to. The basal clays here, as elsewhere, often lie in an eroded hollow in the Bagshot Sand, and at the junction one or more seams of ironstone have been formed, which were formerly somewhat extensively worked. This ironstone is well exposed in the Fir Grove brickyard, rather more than half a mile south-east of Weybridge Station. Here it lines the basin in the sands in which the Bracklesham Clays have been deposited. At the south-east corner of the workings it occurs as a single definite bed, about 8 ins. in thickness, dipping at an angle of more than 30° towards the centre of the pit. In other parts of the pit the ironstone occurs in a number of little seams scattered through a thickness of some 2 ft., partly in the basal clays and partly at the top of the Bagshot Sand. A specimen from the single bed here was analysed by Mr. Radley and found to contain 33·46 per cent. of Fe_2O_3, free from titanic acid.

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[1] *Quart. Journ. Geol. Soc.*, vol. xliv, 1888, p. 609.
[2] *Quart. Journ. Geol. Soc.*, vol. xliii, 1887, pp. 447-456.
[3] *Quart. Journ. Geol. Soc.*, vol. xlv, 1889, pp. 636, 637.

At the brickyards the clays are well exposed in several places. The lowest part is a pale lilac or grey laminated clay; the laminae, which average half an inch in thickness, are comparatively hard and separate readily, giving a shaly appearance to the beds; in some of the partings little lenticles of white sand occur while others show minute seams of ironstone. These clays are exposed to a depth of 8 ft. in the old face at the northern end. In the southern part a few bricks were made in the winter of 1910-11, and the section is fresher; not more than 4 ft. of the laminated clays are visible here, abutting directly against the basal iron band; in the south-west corner the large sand-pit shows some 3 ft. of clay filling the basin cut in the sand (see Plate IV, p. 39), and there are several smaller sections in which the junction is exposed. From the evidence available it seems probable that this lower clay completely fills the basin, but that its upper limit is horizontal; if this be so its thickness in the centre must be at least 30 ft. whereas at the margin there is not more than 5 ft. It is succeeded on the east side of the pit by a curious greenish-grey loam about 2 ft. thick, full of little galls of clay, ovoid in shape, formed of concentric layers and about 1 in. in maximum diameter; the appearance of this bed suggests that it ought to contain fossils, but no traces of organic remains other than fragments of lignite were found.

Over the greater part of the pit there is nothing above this bed with concretions except the usual top débris of sand and gravel, but on the northern side there is a foot or two of greenish sand, apparently the base of the Middle Bracklesham. In one old face there is a good example of contorted drift which has caught up the underlying lilac clays in festoons; this section is described below (pp. 81-82).

Some trenches opened in 1913, a short distance south of the pits showed the lilac clay with abundant crystals of selenite.

The lower clays are also seen in a small road-cutting by the drinking fountain near the pond at the west side of the hill, and there is a good section showing the junction with the Bagshot Beds just north of Silvermere Gate, about half a mile east of Bridge Farm. The usual ironstone is seen, but it here forms an even bed and does not appear to lie in an eroded basin. Close to the Walton Common road and on the southern margin of the map some 10 ft. of laminated lilac clays were exposed in a pit at a new house; traces of this bed may also be seen in an overgrown pit a little north of Burwood House.

Of the upper parts of the Bracklesham Beds there are no satisfactory exposures in this outlier. Glauconitic sands and loams are visible at the side of the main ride 200 yds. south of the brickyard cottage and also below the south-east spur of the ancient camp. C. N. B.

BARTON BEDS.

Introduction.—Some yellow sands, formerly termed Upper Bagshot Sand, but now held to represent the lower part of the Barton Series, overlie the Bracklesham Beds. The stratigraphical position of these sands was recognised by Warburton[1] in 1824, and they were definitely separated as a subdivision by Prestwich[1] in 1847, who referred them with some doubt to the Lower Barton. A further contribution to our knowledge of these beds was made in 1888 by Messrs. Gardner, Keeping and Monckton,[2] who from a study of their fauna came to the conclusion that if not of Upper Bracklesham age, they could not be newer than the Lower Barton.

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[1] *Trans. Geol. Soc.*, series II., vol. i. 1824, pp. 48-52.

The top of the series is not preserved in any part of the London Basin, and the base was placed by Prestwich at the junction of the sands with the upper clays of the Bracklesham. The base adopted by Polwhele[3] differed from that of Prestwich, and is more difficult to follow in the field. Dr. Irving in 1885 pointed out that there was usually a pebble-bed separating the two divisions, and that it formed a good base to the beds then commonly known as the Upper Bagshot. This view was accepted by Messrs. Gardner, Keeping and Monckton in the paper referred to, and later by Captain H. G. Lyons[4] in his small scale map, showing the contours at which it occurred before the Barton Beds were denuded. It has also been adopted by the Geological Survey in the present map.

Lithological characters.—The Barton Beds consist of light-coloured quartzose sand with occasional beds of loam and clay, and, more rarely, seams of pebbles. Bedding is seldom seen and current-bedding is exceptional. The sand grains are small, sub-angular to rounded, and are for the most part of quartz, the others being flint, felspar, white mica, and glauconite, with some zircon and tourmaline. The colour varies according to the oxides or salts of iron which coat the grains, and to the extent to which humus acids and weathering have affected these oxides. Light-yellow and buff are the colours usually seen, but red and brown, green and grey also occur, especially where decaying vegetation forms the overlying soil. 'Iron-pan,' consisting of sand-grains cemented by hydrous peroxide of iron into a hard and resistant rock, and lying at about a foot beneath the surface, is of wide-spread occurrence. This pan forms in layers averaging 6 to 10 ins. thick, and is very troublesome to gardeners, who are obliged to break through it when planting shrubs and trees. It gives rise to wet, boggy land by forming an impervious layer in the subsoil. Small hollow concretions of limonite, mostly conical or cylindrical, are common, and sometimes show casts or impressions of shells.

Seams of clay are rarely met with in the lower part of the sand, but in the higher beds are not uncommon, as at Olddean Common and Bagshot Heath.

At the base of the division is a pebble-bed varying in thickness from 1 ft. to 12 ft. It is present over most of the area occupied by these beds, and is shown on the map, except at St. George's Hill, where the bed is either very thin or locally absent. It is composed mainly of smooth, black, flint pebbles, associated with a few pebbles of vein-quartz and Greensand chert. The occurrence of chert at this horizon is noteworthy, for so far pebbles of this material have not been found in any of the underlying Tertiary deposits. The basal pebble-bed attains a maximum thickness about Stanners Hill, north-east of Chobham, and there are other exposures about Wellington, South Hill Park, Nine Mile Ride, and on Chobham Common.

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[1] *Quart. Journ. Geol. Soc.*, vol. iii, 1847, pp. 378-409.
[2] *Quart. Journ. Geol. Soc.*, vol. xliv, 1888, p. 608.
[3] *Mem. Geol. Surv.*, vol. iv, 1872, p. 330.
[4] *Op. cit.*, vol. xlv, 1889, pp. 633-639.

Palaeontological features.—The fauna of these sands is scanty, and our knowledge of it derived from badly preserved specimens, usually casts, but sufficient forms have been discovered to indicate the age of the beds. Prestwich[1] gives the following list of fossils:—

Cardium.
Cytherea ?
Cypricardia ?
Fusus ?
Globulus patulus ? *Desh.*
———— sigaretinus ? *Sow.*
Infundibulum trochiforme, *Sow.*
Melania costellata ? *Lam.*
Nummulites elegans, *Sow.*
Ostrea flabellula, *Lam.*
Tellina scalaroides, *Lam.*
Turritella (apparently the sulcifera or terebellata).
———— (carinated and tuberculated species).
Trochus ?
Venericardia (species undescribed).
Voluta.

And of fishes the remains of the
Teeth of Lamna elegans.
Cœlorhynchus rectus.

These fossils were found in the mounds of sand thrown up from the railway cutting at Frimley Ridges, and Prestwich remarks that 'Of the eight or nine species two have a range through all the Eocene series; of the remaining seven, three are common to Bracklesham and Barton; one is chiefly confined to Barton, and the remaining four are Bracklesham forms. That these sands belong to one or the other of these two divisions I have but little doubt. The evidence, such as it is, would rather approximate them to the latter.'

Prestwich then suggests other correlations with beds of the Hampshire Basin, and concludes: 'They may prove to represent the whole of the upper division of the great arenaceous series of Hampshire included between the Bracklesham Bay Beds and the Freshwater Series.'

Little more work towards the elucidation of this question was done until 1888, when Messrs. Gardner, Keeping and Monckton[2] studied the fauna of the Upper Eocene Beds of the South of England.

They had much new material, and many new species of fossils had been discovered; but they were not able to decide definitely the age of the beds. In their paper they remark 'the exact correlation of the (Barton) Sands, or very slightly clayey beds, which alone represent the clayey series of Hampshire in the London Basin is more difficult to determine; but the fauna precludes the idea that the sands of the latter at all correspond to the sandy beds of the Upper Barton of Hampshire. The application of the term Upper Bagshot to them, if implying anything newer than and distinct from the Bartons is misleading. . . . Most of the fauna is of species common to Barton and Bracklesham alike; but a few, such as *Buccinum canaliculatum*, *Volvaria acutiuscula*, *Bulla orbicula*, and *Strigilla rigaultiana*, are confined to the former, the first three being quite peculiar to the Lower Barton. Taking the fauna as a whole we find three species, particularly *Dentalium grande*, peculiar to the Upper Bracklesham, thirty-one species common to the Bracklesham and the Barton; nine species peculiar to the Barton of which three are peculiar to the Lower; and only two, *Nucula similis* and *Strigilla*, to the Upper Barton. . . . There may thus be room for doubt, remembering the great thickness of these beds in Hampshire, as to whether the beds of the London Basin are not partly, or even mainly, of Upper Bracklesham age, but there can be none whatever as to their being Lower Barton if they are Barton at all.'

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[1] *Op. cit.*, p. 393.

[2] *Quart. Journ. Geol. Soc.*, vol. xliv, 1888, p. 606.

Conditions of deposition.—Prestwich considered that the Upper Bagshot Sands were such 'as might have been accumulated in a large bight or bay of open sea,' and Messrs. Gardner, Keeping and Monckton that 'the beds . . . and their fauna was such as might have been found in an open sea of considerable depth.'[1] While Dr. Irving[2] is of opinion that they represent marine-estuarine conditions.

Thickness.—The original thickness of the sands cannot be estimated; at present they are overlain by a thick covering of plateau gravel which was deposited after the beds were tilted and eroded. With a gentle dip towards the south the thickness of the sands increases in that direction, and may slightly exceed 100 ft. at Caesar's Camp, Easthampstead. Four miles to the south-east, at the Bagshot Orphanage well, 228 ft. were traversed, the maximum thickness known in the London Basin.

Extent.—The main mass of the Barton Beds occurs in the south-western part of the map, where it forms a high plateau known as Easthampstead Plain, with Wellington College and Crowthorne on the west and Bagshot on the east. Eastward of the main mass are a number of outliers, of which the largest is about a mile in diameter. They are mostly on Chobham Common, but at St. George's Hill, near Weybridge, is another outlier, the true size of which is obscured by drift.

H. D.

Local Details.

THE BASEMENT PEBBLE-BED.

The pebble bed at the base of the Barton Sands is much covered by sandy downwash, but it is exposed at a number of localities.

Crowthorne Area.—It is exposed in the numerous drainage-trenches in the grounds of Wellington College and was encountered at a depth of 23 ft. in the college well, where it was a foot thick. It is seen behind

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[1] *Quart. Journ. Geol. Soc.*, vol. xliv, 1888, p. 616.

[2] *Geol. Mag.*, 1891, p. 362, 363.

Wellington Hotel, in the railway cutting near the station, and spreads over the fields of the college sewage-farm; and was also dug in the grounds of Sandhurst Lodge and near by at Ambarrow Farm.

Near Ellis Road, in Crowthorne, the bed was dug for road-metal: and is also exposed at White Cairn a little north of the college lakes.

Easthampstead Area.—Exposures are met with round the north of the outcrop, in ditches beside the main road from Crowthorne to Easthampstead and east of this road near Caesar's Camp the pebbles cover a fairly wide area; while at several points in South Hill Park and near Red Lodge pebbles are seen in drainage-trenches.

South Ascot Area.—About a mile further east a considerable spread occurs between the two brick-yards south of Passmore's Cottages. At Kingsride the bed over a foot thick is dug in many pits for road-stone.

There is a conspicuous outlier of Barton Sand at King's Beeches, but the pebble-bed is not exposed nor is it again seen in the valley along which runs the Basingstoke road.

Chobham Common Area.—The pebble-bed reappears in force over the Sunningdale Golf Links, especially by the Dormy House, and also caps the escarpment south of Sunningdale Railway Station. From this point it extends south to King's Hill and east beyond Titlark's Farm. In the plantations behind the farm it was dug for road-metal and the old pits show 3 ft. of pebbles, many of them large, mixed with coarse and fine sand. Around the fairly large outlier of Ribsden and at Fox Hill, north-east of Windlesham, it has not been found, but around Staple Hill on Chobham Common its pebbles are strewn over the moor. It outcrops on the eastern side of Ship Hill, and about a mile west of Longcross House, at Oystershell Hill, capping that hill as far as the cross roads. A little further east at Barrowhills the pebble-bed crowns three conspicuous knolls, on one of which many pebbles were dug out during excavations for a reservoir and water-tower.

The finest section of this basement bed anywhere in Sheet 269 is at Stanners Hill. In a field about 100 yds. south by east of the farm is a pit 11 ft. deep, where the pebbly bands are interstratified with sand, and sloping south-west at 20°; the pebbles range up to 4 ins. in length, but average approximately 1 in. The stones smaller than these compose the coarse sand, and of this there is a large quantity. Black flint is the commonest constituent; while chert from the Lower Greensand is found occasionally and vein-quartz is by no means rare. The sand, though composed principally of quartz, contains glauconite grains in abundance as well as flint, but the ratio of quartz to flint is much greater in the sand than in the coarser material. H. D.

The pebbles cover the whole hill-top and the beds are exhibited in many large pits on the Common and in Stanyard's Park. At a small pit in a field just north of the Park about 6 ft. of the pebble-bed is exposed: here quartz-pebbles are far more abundant than chert, and one piece of ironstone 4 ins. long, like that occurring in place in the Folkestone Beds, was found. The northern part of this outlier is known as Fern Hill; here yellow sands of the usual type lie above the pebble-bed and form a round hillock about 200 yds. in diameter and 30 ft. in height. Just below the pebble-bed on the western flank a strong spring is thrown out by the clayey Bracklesham Series. C. N. B.

Bagshot Area.—On the eastern side of the outcrop the basement bed has been trenched at Queen's Wood, west of Bagshot Park, and encountered in a well at Waterer's Nursery, Bagshot, below 25 ft. of sand. At Turf Hill, south of Lightwater, it underlies yellow sand, and also at New England in two large pits, and again in a deep trench alongside the grounds of the Gordon Boys' Home.

Another small outlier occurs east of the above, round the laundry belonging to Queenwood House; there are several old pits now disused, showing the pebbles, but the overlying sands are absent.

Timber Hill, near Ottershaw Church, is capped by this pebble-bed.

Crowthorne Area.—On the main outcrop the grounds of Wellington College are for the most part composed of Barton Sand which extends thence under the village of Crowthorne, where it is exposed in many small pits. The new road at Pine Hill, north of Edgbarrow Hill, was cut through a low hill where 20 ft. of red and orange, unbedded sand underlie 6 ft. of plateau gravel. Another deep cutting at Circle Hill, the north end of the village, showed 20 ft. of unbedded yellow sand. A thin seam of clay was dug for garden-use in a pit in Napier Road, Lodge Hills, but clay is rarely seen in this area. At the College rifle-range there is a section of silver and light yellow sand which contains also dark grains of tourmaline in small quantity. These sands extend towards Sandhurst and were exposed when the railway cutting was made near Sandhurst Lodge at a place called Ambarrow Hill. Here Mr. Monckton[1] found many badly preserved fossils, among which *Natica, Xenophora* and *Voluta* were abundant and recognisable; also a cast of *Turritella imbricataria.*

Near Wildmoor Bottom, north of Sandhurst, there are sections of orange and buff sand with ferruginous concretions and traces of fossils. The boundary between the Barton and Bracklesham Beds is difficult to trace in this valley on account of the water-logged condition of the sands overlying the Bracklesham Clays. A small outlier forms the dry land of Werg Hill by Owlsmoor Church.

At the Rifle-Butts near the Royal Military College Hospital a fine section of the sand is seen and fossils were found at Windsor Ride, near Woodman's Lodge, by Prestwich and other observers.

Bagshot Park Area.—Approaching Bagshot, the bridle paths around Surrey Hill follow deep cuttings in yellow sands containing many dark grains and iron concretions. In a road-cutting near the summit of the hill seams of yellow clay up to 1 ft. in thickness are interbedded with the sand and mark a higher horizon in the Barton Beds. These clay-beds are exposed where little streams cut through the gravels of the plateau. They were unusually well seen on the west side of Paschal Wood in pits which are now partially overgrown. In 1910 the pits showed 5 ft. of yellow, green, and orange laminated clay with ferruginous concretions and traces and casts of fossils.

The same beds appear on the south side of the valley but at a lower level, and also near Pennyhill House beneath the famous 80-ft. Holly Hedge. They next appear on the east side of Olddean Common, where Messrs. Gardner, Keeping and Monckton[2] obtained a *Xenophora*, another univalve and a bivalve.

The sands were at one time exposed in the deep railway cutting north-east of Camberley but are now grassed over. A well at the Royal Albert Orphan Asylum passed through 228 ft. of Barton Sand, the maximum thickness of Barton Beds preserved in the London Basin. About ¼ mile south-east of the Asylum clay was dug and made into bricks which were used in the building. It is rather a tough, yellow to brown clay and produced a red brick.

The heath-clad undulating hills stretching beyond Curley Hill form picturesque moorland scenery. Exposures are scarce, but the clay-beds are visible near the reservoir of the Frimley Waterworks, also near the well-known Black Pond, and to the east of Curley Hill.

The ground then slopes steeply eastwards so that the top beds of the Bracklesham series outcrop from beneath the sands near the Folly. But Barton Sands with their basement pebble-bed reappear at Turf Hill and are seen at New England in two large pits, showing 20 ft. of yellow, buff, and orange sands with iron concretions.

On the eastern margin of the main mass sections occur near Lightwater and Bagshot. An outlying mass forms an island in the midst of swampy fields near Bagshot Green in which a large pit exposes 20 ft. of yellow, white, and orange sands with traces of bedding planes, a feature rarely seen in these sands.

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[1] *Rept. Wellington College Natural Sci. Soc.*, 1890, p. 69.
[2] *Quart. Journ. Geol. Soc.*, vol. xliv, 1888, p. 613.

Easthampstead Area.—The northern outcrop extends from Crowthorne, to near South Ascot. At Caesar's Camp about 50 ft. of buff and light yellow sands are cut through by the road, and at Gravel Hill similar sands are exposed. Further east is found what is perhaps the best section of the Barton Sands in Sheet 269; this is at Tower Hill at the north-eastern end of the main outcrop. The sands are stratified, mostly yellow with many dark grains and patches of greenish-grey sandy loam. The pit is about 20 ft. deep all in sands of Barton age. No identifiable fossils could be found, but traces of gasteropods were not uncommon.

The basement pebble-bed was dug for gravelling the carriage-drive in the neighbouring ground at Tower Hill House.

Outliers.—There is an outlier of the Barton Beds at Duke's Hill, near Fernhill Allotment, where the junction with the Bracklesham Beds was laid bare in 1910 during the making of the Swinley Park Golf Links. The outlier extends to the east of the railway and in the cutting shows 2 ft. of gravel resting on 3 ft. of coarse red and yellow sand (loamy in places) with 10 ft. of fine-grained yellow sand below. A line of bunkers was made near Fern Hill, the lower ones in clay and the upper in yellow, powdery sand, while yellow and white sand is dug in a pit near the adjacent railway-bridge. A quarter of a mile further north along the railway Mr. Monckton[1] recorded the basement pebble-bed and overlying sand which was also dug when the foundations of the Golf Club House were made.

There is a conspicuous outlier at King's Beeches, Sunninghill, and a still larger one at Ribsden, near Windlesham. The sands here attain a thickness of 60 ft., as proved by a well at the Camp, where 40 ft. of sand was dug through; the well mouth being 20 ft. below the top of the hill.

A pit near the south boundary of the golf links shows 2 ft. of gravel overlying current-bedded yellow sand with glauconitic grains and beds of laminated clay and clay pellets. Though generally rare in the Barton Sand, current-bedding is exhibited in several sections in this outlier, best, perhaps, in a large pit at Fox Hill where some buff and yellow sand contains strongly current-bedded brown layers of sandstone.

Staple Hill consists probably of Barton Sand, for it rises about 30 ft. above a flat moor which is strewn with remains of the pebble-bed.

H. D.

St. George's Hill.—The remaining outlier is on St. George's Hill, in the south-east corner of the map; it was not shown as Upper Bagshot [Barton] on the Old Series map, but its true age was recognised by H. B. Woodward[2] who was accompanied by Mr. Monckton at the time of his visit to this locality.

Yellow sands, of the usual structureless aspect, form a long narrow belt just below the summit of the hill, except at the north end, where the plateau gravels rest directly on the Bracklesham Beds. The sands are exposed beneath the gravel in pits on either side of Main Ride, and at the time of the recent survey about 6 ft. of these beds were still visible; but the workmen stated that not many years ago they dug through 17 ft. of the sands without finding any change in their composition.

The junction of the Barton Beds with the Bracklesham is greatly obscured by thick vegetation and the downwash from the overlying gravel. That useful guide, the basal pebble-bed, is generally absent, but it has been found on the extreme south of the hill and shows that fully 50 ft. of the Barton Beds are present. The best exposure of the sands is in an old road-cutting near the north-eastern corner of the ancient camp. Here yellow sands seen to about 40 ft. pass down gradually into glauconitic sands of the Bracklesham, which were exposed by an uprooted tree. Another little exposure has been made at the side of the Main Ride a little way below the ramparts of the Camp on the south-west, where the bank has been cut into to make room for a well.

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[1] 'The Bagshot Beds of the London Basin.' Privately published by T. and A. Constable, Edinburgh, 1893.

[2] *Proc. Geol. Assoc.*, vol. xxii, 1911, p. 239.

Several springs are thrown out at the base of the sands by the clayey beds of the Bracklesham, one of which is of interest as it afforded a water-supply for the camp:[1] a special entrenchment, which leaves the main rampart of the north-east side at the point where the road now enters, was thrown out to defend this spring and it is possible that a small dam was made to hold up the water. C. N. B.

GREYWETHERS OR SARSEN STONES.

At many localities there are large blocks of grey standstone or quartzite which usually lie at or near the surface of the Barton Sand and under the superficial gravels. They occur in nearly all the gravel pits on Chobham Ridges but are especially common at High Curley and Cock-a-Dobby, Sandhurst, and have also been described from other pits by Mr. Monckton.[2] They were abundant in the grounds surrounding the 'Camp' (the residence of the late Sir Joseph Hooker), whence they were carried to build the waterfall at Virginia Water. Though in no case actually seen *in situ* in the Barton Sand, the position of some of these sarsens, as at the Camp and High Curley, suggests that they have not been derived from a distant source.

The question of their origin has been considered by Prestwich,[3] Whitaker[4] and others. Prestwich thought that most of the sarsens had been derived from the Woolwich and Reading Beds, a conclusion with which Whitaker was in agreement; and as they have been described[5] as occurring *in situ* in these beds at several localities there is no doubt that this is a possible source. But as they frequently rest on Barton Sand under conditions that do not suggest their transportation, it seems probable that they may have been formed in the Barton Beds. Similar sandstones indurated by silica (called locally 'pierre de grotte') are common in Belgium in the Bruxellien or Calcaire grossier, the equivalent of the Bracklesham Beds.

Formerly the uses of these stones for many purposes gave rise to an active local industry. They were trimmed into paving setts, coping and building stones and doorsteps, as may be seen by the many examples in neighbouring churches and in Windsor Castle. H. D.

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[1] Gardner, E. *Surrey Archæolog. Collections*, vol xxiv, 1911.

[2] *Quart. Journ. Geol. Soc.*, vol. liv, 1898, pp. 184-193.

[3] *Quart. Journ. Geol. Soc.*, vol. x, 1854, pp. 123-130.

[4] 'Geology of London.' Vol. i, *Mem. Geol. Surv.*, 1889, pp. 478-480.

[5] Monckton, H. W., *Proc. Geol. Assoc.*, vol. xxii, 1911, p. 240; and W. Whitaker. *Op. cit. supra*, p. 479.

CHAPTER V.

PLATEAU GRAVELS.

Mode of occurrence.—Scattered over the southern half of the area included in the map are numerous tracts of gravel occurring with a generally even surface at heights varying from 150 to 400 ft. above sea-level. Although no contemporaneous fossils have been found in these gravels, they have so many characters in common that they may be grouped together under the one designation of Plateau Gravel.

The two largest, and highest, of these gravel deposits lie in the south-western part of the map; the one nearer Crowthorne forms Easthampstead Plain; the other occupies a large part of Bagshot Heath. These two tracts were apparently once continuous with a mass which stretches some miles to the south, capping the Chobham Ridges and Fox Hills, and throughout its length forms the highest ground east of the river Blackwater: a similar high-level gravel occurs on the western side of the river. To the main southerly mass the smaller patches which lie scattered to the northward form a wide ragged fringe in which the general surface of the individual patches slope downwards towards the north.

Presuming, therefore, that the gravels are the remnants of a once-continuous sheet, they appear to have been deposited in a fan on a sloping surface which conformed in its general outline to the present configuration of the Thames valley.

Composition.—The constituents of these gravels, though essentially similar throughout the district represented on the map, are subject to wide local variation in their relative proportions. They were well described under the term 'Southern Drift,' by Prestwich.[1]

During the recent survey the proportion of the several constituents was estimated at each exposure, and it was found that the chief variations were an increase in the proportion of Lower Greensand chert in the gravel of the outer belts; and the incoming on the east of chert of different texture and character. The kind of chert met with most commonly is pitted with numerous minute hollows and crowded with sponge-spicules often visible to the unaided eye. This chert is certainly of southerly origin, and probably derived from the Lower Greensand of the high ground about Hindhead. The more easterly type of chert, also probably derived from some part of the Lower Greensand, is first met with near Ribsden (Chobham Common), and is solid, banded, of a deep reddish-brown colour, and resinous lustre.

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[1] *Quart. Journ. Geol. Soc.*, vol. xlvi, 1890, p. 156.

In the finer constituents the variation is even more marked, as shown by the following analyses by Monckton.[1] The percentages are by weight:—

	Wagbullock Hill. 400 ft. O.D.		Coppid Beech Lane. 300 ft. O.D.	
	Large Material.	Small Material.	Large Material.	Small Material.
Subangular flints	73·8	41·9	50	25
Flint pebbles from Tertiary Strata	22·1	35·7		24
Chert from Lower Greensand ...	4·1	8·9	50	34
Quartz	—	13·4	—	15

It is evident, then, that the gravel is composed of materials derived from three chief sources, namely, the Tertiary Pebble Beds, the Chalk, and the Lower Greensand. The Quartz was possibly derived either from the Tertiary Beds or the Wealden.

The gravels as a whole are distinctly current-bedded, though this character is more conspicuous in some pits than in others. The bedding is shown by alternations of gravel and sand. While such pebbles as chert and little-worn flint indicate a somewhat distant origin, much of the sand has been derived from more local sources; at times it consists so largely of Bagshot material as to simulate Bagshot Beds *in situ.*

In the description of the map immediately to the west[2] it has been pointed out that the drift gravels of that area are divisible into three types as follows:—

(1.) Contains many small pebbles of vein-quartz associated with abundant flints derived from the Chalk and the Tertiary Beds, but no Greensand chert nor Bunter pebbles. This may conveniently be called the Western and South-Western drift.

(2.) Contains fewer vein-quartz pebbles, while in addition to the usual flints, Greensand chert is present and often in considerable quantity but no Bunter pebbles.

(3.) Contains Bunter pebbles in addition to the usual flints, etc., and may be called the Bunter pebble drift. It stretches across the whole northern part of Sheet 268.

From the notes on the distribution of these constituents, given in the Memoir referred to, the separate areas over which these different types of gravel occur can be readily defined. The boundary between 1 and 2 runs approximately north and south from Strathfieldsaye toward Reading; while the southern boundary of No. 3, the Bunter drift, trends in a curving line roughly from west to east, crossing the boundary between 1 and 2 at right angles. This relationship clearly implies that the gravel with Bunter pebbles is somewhat newer than both of the other types.

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[1] *Quart. Journ. Geol. Soc.*, vol. xlviii, 1892, pp. 35, 36.

[2] 'Geology of the Country around Reading.' *Mem. Geol. Surv.*, Explanation Sheet 268, N.S., 1903, pp. 63-75; and H. W. Monckton, *Quart. Journ. Geol. Soc.*, vol. xlviii, pp. 29-47.

In the present map none of the high-level gravels contain Bunter pebbles, while Lower Greensand chert occurs in all. They correspond, therefore, to the type No. 2 of the foregoing description. Their composition strongly suggests that the material has travelled from south to north, and this view is supported by the fact that the boundary between 1 and 2 in the adjacent map also trends from south to north.

Various modes of origin have been suggested for these gravels, or for portions of them; thus the large masses at the 400 ft. contour about Easthampstead Plain have been supposed[1] to represent the flood deposits of an old valley which have escaped denudation owing to their greater resistance, while the entire surrounding surface has been removed. But on the assumption that the supposed valley ran from south to north[2] the distribution of the gravels at the 400 ft. level in the area south of the present map, and those on the present map as shown on the Old Series map, Sheet 8, would require the bottom of the valley to have been many miles wide from east to west. The existence of such a topography at the date required seems improbable in view of the occurrence on Netley Heath of what are possibly marine Pliocene deposits. Again the suggestion involves the separation of this special portion about the 400 ft. contour from the remainder of the gravels at lower levels.

Dealing with the gravels as a whole Dr. Irving[3] has suggested that they represent the fan-shaped masses of debris carried down by torrents from the Wealden heights; and are comparable with the schötter-gravels of the Lower Alpine valleys. But it may be objected to this hypothesis that the outwash fans of the Alps lie in defined hollows, while the gravels here dealt with rest on a surface which both as a whole and in some particular parts is more or less convex. Gravels so arranged are often found in association with Glacial deposits in such manner as to imply that the gravels have had their origin as 'outwash fans' from ice-sheets. Though no such association can be proved in the present instance, there seems to be much probability that these plateau gravels are of Glacial age, and are due in some way or other to glacial conditions, and probably represent an outwash from the snow or ice-covered high-ground to the south around Hindhead. This view is supported by the fact that they abut against and are more or less mingled with Bunter-pebble gravels which in the area to the north-east are intimately associated with and often underlie the Chalky Boulder Clay. It has been mentioned above that in the Reading area the two types of gravel are in contact along a line more or less parallel to the Thames, and a little to the south of it, while to the east at Richmond and Wimbledon Hills[1] they are united in a single sheet. The 'chert-gravels' are probably somewhat older than the gravels with Bunter pebbles, but the full evidence implies that the difference in age can be only slight; so that if the Bunter gravels belong to the Glacial period, the chert-gravels may also be fairly assigned to that period.

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[1] Monckton, H. W. *Quart. Journ. Geol. Soc.*, vol. xlviii, 1892, p. 33.

[2] Monckton, H. W., *op. cit.*, p. 33; and Rev. A. Irving, *op. cit.*, vol. xlvi, 1890, p. 561.

[3] *Quart. Journ. Geol. Soc.*, vol. xlvi, 1890, p. 559.

When viewed from a distance the flat-topped hills capped by chert gravels appear to be arranged in three tiers, at decreasing levels and partially encircling the 400 ft. platform. This arrangement has been adduced as evidence of the deposition of the gravels by a river, the tiers being supposed to represent successive terraces. This argument might apply if the gravels were confined to the levels of the tiers. But this is not the case, as they occur also at intermediate heights, and it is evident that their rudely terraced aspect is due to original features of the surface on which they were deposited. The flat-topped hills though appearing to be the relics of gravel terraces cut up by denudation, are the remains of features due to the variable composition of the Eocene strata, of which the sandy beds weather out as flattish ledges or terraces, and the clays form long slopes becoming steeper where they immediately underlie the sands. The gravel deposited on the flat surface of the sandy beds would come quickly to rest, while the immediately adjacent clay-slopes were generally too steep to retain the deposit, which was therefore carried further downhill to lodge on the more gentle clay-slopes beyond the steeper part of the feature. If any particular level be followed, it will generally be found that the gravels developed along it rest sometimes on sand and sometimes on clay, and that the terrace-like features are merely accidental to the general spread of the gravel over an uneven surface.

The chert-gravels occur again capping St. George's Hill in the south-east corner of the district, at a height of 250 ft. above O.D. But in this case it seems probable that the characteristic cherts, etc., were derived from the area south of Guildford, and were brought down approximately along the course of the Wey.

H. D.

Local Details.

The gravel forming the plateau of Easthampstead Plain and Bagshot Heath is not often exposed, but there are some large pits where it is worked for road-metal, which show sections up to 20 ft. in height. These will be described as they occur from south to north.

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[1] Monckton, H. W. *Quart. Journ. Geol. Soc.*, vol. xlix, 1893, p. 316.

Bagshot.—The first of these pits is at Curley Hill or High Curley, a mile south of Bagshot village, where the following beds are exposed:—

	Ft.
Gravel and sand	6
Sand, current-bedded	2
Gravel	3
Sand, current-bedded	2
Coarse gravel with many large sarsen stones, bottom of gravel not reached	3
	16

There are many old pits in the neighbourhood of the Royal Albert Orphanage and at Black Hill, where large sarsen stones were commonly met with. One stone[1] measured 14¼ ft. by 11¾ ft. by 4 ft.; and twenty-five others were found in the same pit.

None of the pits on Bagshot Heath require detailed description. They all contain sarsen stones and casts in flint of echinoderms and molluscs from the Chalk, while the gravel is of uniform composition. Near New England Hill a pit showed some 12 ft. of interbedded coarse sand and gravel, consisting of subangular flints and chert, with pebbles from Tertiary Beds and small white quartz pebbles. The top layers are contorted and the lower contain many sarsen stones.

About half a mile west is another pit where 27 ft. of current-bedded sand and gravel is seen. The largest pit is at Caesar's Camp, where the following sequence was observed:—

	Ft.	in.
Weathered sands, and gravel composed of Tertiary pebbles and sub-angular pieces of flint and chert with quartz pebbles	3	0
Coarse-grained ferruginous sand	0	6
Large sub-angular flints and smaller pebbles and chert in coarse sand stained brown by oxides of iron	0	10
Coarse mottled green and red fine sands and loams	1	0
Interbedded coarse sand and gravel with large water-worn flints and small pebbles, with some chert	6	0

The top beds to a depth of 4 ft. were contorted and disturbed, while the lower beds were evenly stratified.

Prestwich[2] gives the following analysis of this gravel:—

	Per cent.
1. Sub-angular fragments of flint, part not stained, and part stained yellow and brown	40
2. Tertiary flint-pebbles, of which about one-fifth part are broken	32
3. Much-worn fragments of light-coloured ragstone and yellow chert, and ironstone-grit	18
4. Small pebbles of white quartz	4
5. Pebbles of white sandstone and sub-angular fragments of sarsen stone (Tertiary)	6
	100

At Wagbullock Hill there is another large pit, with the top layers thrown in waves inclining towards the west. Mr. Monckton's[3] analysis of this gravel has already been quoted (p. 60).

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[1] Monckton, H. W. *Quart. Journ. Geol. Soc.*, vol. xlviii, p. 34; and vol. liv, p. 188.

[2] *Quart. Journ. Geol. Soc.*, vol. xlvi, 1890, p. 160.

[3] *Quart. Journ. Geol. Soc.*, vol. xlviii, 1892, p. 35.

The gravels occurring at lower levels resemble those of Easthampstead Plain, but sometimes contain a larger amount of chert, besides local variations in other respects. They are roughly stratified, or current-bedded; some are mottled and their upper layers are usually contorted or disturbed. The large blocks of sarsen stone found so frequently in the higher gravels are much less common at lower altitudes.

Bracknell—Gravel is found capping hills about 300 ft. above O.D. near Amen Corner and at the top of Coppid Beech Lane. At the latter locality the gravel and sand is about 7 ft. thick and contains 20 per cent. of chert and large tabular pieces of iron-cemented conglomerate or 'pan.' The base of the gravel is stratified, the overlying sand current-bedded, and the top gravel disturbed and contorted. In the undisturbed gravel the stones lie with their long axes horizontal, while in the disturbed beds their axes are vertical, and the gravel lies in large clots in sand.

Analysis of the finer constituents of this gravel showed their following proportions by weight:—

	Per cent.
Subangular flints	25
Tertiary flint pebbles	24
Chert	34
Quartz pebbles (small)	15
Iron concretions from Bagshot Beds	1½

The gravels at Wick Hill, Bracknell, and at Long Hill and Chavey Down, Ascot, are similar to those just described. Prestwich says: 'On Cherry (Chavey) Down near Ascot subangular fragments of chert and ragstone are so abundant that they almost equal in number the subangular flints, which with flint pebbles and a few fragments of iron-sandstone, constitute the other portion of this gravel. They are imbedded in a yellow quartzose sand with some black grains and quartz grit.'[1] Monckton[2] calls attention to the occurrence at Chavey Down of the sandy drift which overlies so much of the country thereabouts and towards Chertsey; and to the inclusion of 'blocks of yellow and white sand and bits of clay lying at all angles; one of the blocks being 1 ft. 8 in. by 10 in.' He concludes that these blocks 'are clearly derived from the Lower Bagshot Beds, and . . . that the whole is of glacial origin.' H. D.

Shurlock Row.—Still further north we find gravels which probably represent the outermost part of the original fan, though perhaps at some localities they may have been rearranged at lower levels since they were first deposited. The lowest level at which they occur is about 150 ft. O.D. at Honeys, which is also near their northern limit; here the iron-pan forms a hard and durable conglomerate; it is not more than 2 ft. thick, but was visible at the time of the survey in a newly-sunk well. In the outliers between Billingbear and Shurlock Row are several small pits, mostly disused, which call for no special description.

Winkfield.—By the cross-roads between Warfield Hall and the village there is an old pit now showing some 2½ ft. of gravel in which resinous cherts are fairly abundant, whereas to the west these do not occur. Round Hawthorn Hill, Foliejon Park, New Lodge, and Winkfield the most noteworthy feature of the gravels is the very strong iron-pan; the resultant conglomerate is sufficiently durable to be used as a building stone, as may be seen in Warfield and Winkfield churches.

In the triangle of roads between Warfield Grove and Park there are some large pits in the gravel. The best section is some 8 ft. in height; the upper part shows the usual contortions remarkably well (see Plate V.) and

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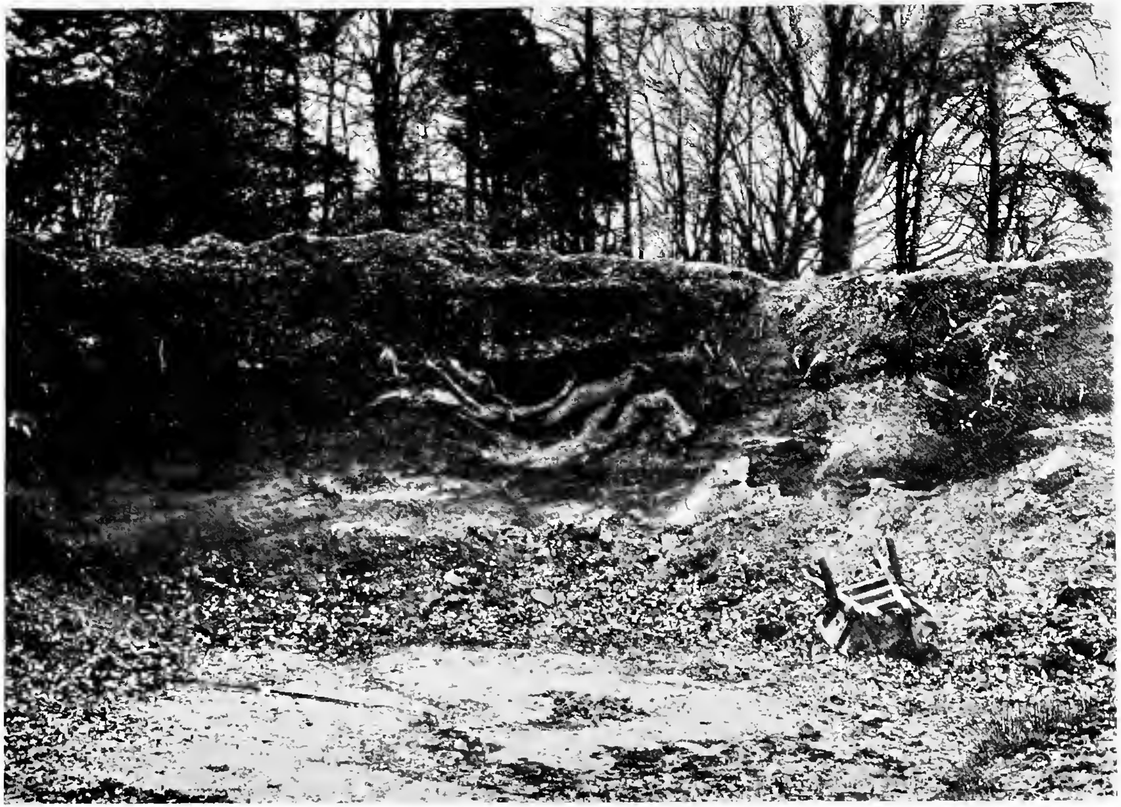
[1] *Quart. Journ. Geol. Soc.*, vol. xlvi, 1890, p. 160.
[2] *Ibid.*, vol. xlviii, 1892, p. 43.



PIT AT WARFIELD.
Contorted Gravel.

is markedly more stony than the lower 4 ft. seen, which consist mainly of yellow sand with pebbles scattered here and there through it. The base of this sand is highly glauconitic and is evidently derived from Bracklesham Beds. Below this the workmen state that a bed containing large irregular flints and sarsen stones occurs, resting on the London Clay; a sarsen lying in the pit at the time of our visit was some 3 ft. in maximum length, with a well-polished surface. Amongst the flints from these pits we noticed an unusual number that showed smooth polished facets. In the grounds of Warfield Grove the gravel was formerly worked to a depth of 15 ft.

C. N. B.

Ascot and Sunningdale.—Sandy gravel underlies part of the racecourse at Ascot and extends thence southwards to Englemere House and northwards to near the Royal Kennels. It is present at Sunninghill and caps the spurs of high ground on either side of Sunningdale, whence it is traceable eastwards across the London Road to Portnall Woods. The gravel forms the wide spreads shown on the map to the north of the hills just mentioned. These sheets are level from south to north and lie near the 200 ft. contour line. They cover the wide plain of Smith's Lawn and extend to Parkside, and within this area were worked formerly for roads and paths. In the old pits the gravel is seen to be current-bedded, and contains some 20 per cent. of chert.

Similar low plateaux are seen east of the main road at Wood Lee and Callow Hill.

New Egham.—To the north Plateau Gravel is met with round Bishopsgate and Englefield Green. In this district much difficulty was found in discriminating between the gravel and the Bagshot Pebble-bed which forms the surface round New Egham. The relative abundance of chert in the fields is a fairly safe criterion, as that material does not occur in the Bagshot Beds, but in the absence of sections the boundaries shown on the map are necessarily more or less hypothetical.

Chobham Common.—From the neighbourhood of Virginia Water the gravels extend towards the south with a steady rise and are preserved on isolated hills as at Knowle Hill, Childown, Staple Hill, Fox Hill and Round Hill. At Long Down and Ribs Down, at 300 ft. O.D., the gravel contains over 40 per cent. of chert, and 30 per cent. at King's Hill. In the wood at Pear's Hill a pit worked for sand and ballast shows an interesting section:—

NORTH END OF GRAVEL PIT AT PEAR'S HILL.

	Ft.	in.
a. Current-bedded gravel consisting of coarse subangular red sand with many abraded and water-worn stones, sponge-cherts, flinty cherts and chalk flints	5	0
b. Current-bedded yellow and glauconitic sands, the lower half of the sand includes pellets and almond-shaped pieces of light-red and ochreous clay mixed with a few stones in glauconitic sand. This bed extends for 15 ft. and then thins out	2	0
c. Laminated buff and light brown loam	0	3
d. Lilac and grey clay in lenticles; contorted in places	0	3
e. Laminated yellow sands; seams of glauconite and pipe-clay; strongly current-bedded at S. end of the pit	1	0
f. Yellow sand, glauconitic	2	0
g. Coarse grain sand (red and iron-stained) with pebbles of flint and fragments of chert	1	0

These sands and clays are obviously derived from the Bracklesham Beds, but now rest upon Barton Sands.

A wash from the Barton Beds covers the hill at Heathpark Wood as far as Updown Hill and Windlesham.

There is about 2 ft. of gravel on the hill behind the Camp where a great number of large sarsen stones was found (see p. 93).

Crowthorne.—On the west of Easthampstead Plain, is a group of hills some 300 ft. in height, covered with current-bedded gravel. At Pine Hill, Crowthorne, an interesting section is exposed in a gravel pit, where 2 ft. of bleached gravel rest on green sand including clusters of pebbles. These pebbles range in size up to a diameter of 3 in.; some are discoid, others irregular and angular and many break at a touch into numerous small scales, as though they had been cracked previously and loosely held together.

Similar gravel is found at Edgbarrow and Long Down. The gravel pits at Long Down, well known locally under the name of Cock-a-Dobby Pits, yield a valuable gravel for roadmaking which attains a thickness of about 12 ft.

Some patches of gravel of sufficient dimensions to be shown on the map are entirely unstratified and may represent reconstructed material carried by later storm waters downhill from the higher stratified deposits.

H. D.

St. George's Hill.—As mentioned above the gravels which crown St. George's Hill seem to be a relic of a fan of material brought down from the Wealden heights lying to the south of Guildford just as those further west radiate from the hills about Hindhead. As the latter can be traced northwards and westwards till they meet the northern Bunter gravels in a single deposit near Reading, so the series of which the St. George's Hill gravels form part can be traced northwards and eastwards to Richmond and Wimbledon Common, also a joint northern and southern deposit.

No trace of northern material has ever been found in the gravel of St. George's Hill; Prestwich gives the following analysis of its composition:—

	Per cent.
'1. White and yellow-stained subangular flints	44
2. Tertiary flint-pebbles, some broken	30
3. Subangular fragments of ragstone and brown chert ...	15
4. White quartz-pebbles	5
5. Pebbles of sandstone, ironstone, &c.	6
	100

in a matrix of quartzose sand.'[1]

In addition to the above the presence of small blocks of sarsen stone was noted during the recent survey; they are also recorded by H. B. Woodward.[2]

There are several small pits now disused, and near the centre of the plateau some large workings shown on the map. 'The longest face of the working is 45 yds., with a mean depth of a little under 9 ft. . The gravel rests on a slightly undulating surface. It is moderately sandy in places and includes a piece of argillaceous Middle Bagshots [Bracklesham Beds] about 1 ft. long. But the most striking feature in the section is a mass of brownish sand, 11 yds. long and about 2 or 3 ft. thick, occurring in the midst of the gravel in such a way as to suggest the idea that it had been floated bodily into that position.'[3] The usual contortions are well seen in some parts of the pit.

On the flanks of St. George's Hill there are some small outlying patches of gravel which are shown on the map by the the same colour as the main mass, but they lie at a somewhat lower level and are probably rearranged.

C. N. B.

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[1] *Quart. Journ. Geol. Soc.*, vol. xlvi, 1890, p. 159.

[2] *Proc. Geol. Assoc.*, vol. xxii, 1911, p. 239.

[3] Hudleston, W. H. *Quart. Journ. Geol. Soc.*, vol. xlii, 1886, p. 168.

CHAPTER VI.

RIVER DEPOSITS.

General Account.

The deposits of sand, gravel and brick-earth that can be definitely connected with the modern Thames occupy a wide area in the north-eastern part of the map (see Fig. 1), and can be separated according to their relative heights above the river into three distinct terraces or shelves. The gravels of these terraces are indicated on the map by three shades of colour. The highest (most deeply coloured on the map) lies on what is often known as the 100-Ft. Terrace, and the middle (less deeply coloured) on the so-called 50-Ft. Terrace; to these we have applied the local terms 'Boyn Hill' and 'Taplow Gravel' respectively, while the lowest, but little above the modern alluvium, is conveniently known as the Flood-plain gravel. The highest terrace maintains a height of approximately 100 ft. above sea-level in the London area, and for many miles to the east, but when traced up the valley it steadily rises; at Maidenhead it is 140 ft., while at Oxford it is 240 ft. above O.D.: hence the term '100-Ft. Terrace' is only locally applicable, and for a similar reason, the name '50-Ft.' for the middle terrace of this area is inappropriate. The place-names we have adopted for the two terraces in lieu of these terms are taken from localities in the adjacent map to the north (Sheet 255), where the relation of the terraces to the modern river is clear, and the respective gravels have yielded flint implements of well defined characters.[1]

In the present area the gravel of the Boyn Hill Terrace is usually separated from that of the Taplow Terrace by an outcrop of bare rock, whereas the Taplow and the Flood-plain gravels are generally in contact with one another. The brick-earths associated with the river-gravels are found for the most part near the northern margin of the map, where they overlie the gravels of the Taplow Terrace, and to some extent overlap the southern or basal lower margin of the Boyn Terrace, obscuring the feature that separates the two. There are also a few small patches of this material that overlie and are younger than the gravels of the flood-plain. The Alluvium is not of great extent or thickness, the widest spread being that bordering the various branches of the River Colne.

These divisions of the river deposits of the Thames appear to correspond with the sequence of types of flint-implements. The Boyn gravels are characterised by implements of Chellean and Acheulian types; while that of Le Moustier first appears in the Taplow Terrace, though this contains also occasional specimens of the older forms which are probably derivative. Thus at localities as far apart as Boyn Hill,[1] near Maidenhead, and Swanscombe,[2] near Dartford, the two older types of implements have been obtained from the highest terrace, while the Mousterian has been met with in the Taplow gravels at Dawley, near West Drayton and also at Northfleet, Kent.[3]

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[1] 'Summary of Progress of 1911.' *Mem. Geol. Surv.*, 1912, Appendix II., pp. 74-77.

The conditions under which the successive terrace deposits of the Thames were formed may be provisionally tabulated as follows:—

1. Boyn Hill Terrace. Stage of rapid deposition of coarse gravelly material by the overloaded river in a broad shallow valley.
2. Stage of corrosion, during which the bottom of the valley was lowered by not less than 40 ft., partly by the removal of the older gravels and partly by renewed excavation of the underlying solid formations.
3. Taplow Terrace. Second stage of deposition; gravels and sands succeeded by brick-earths.
4. Second stage of corrosion, during which the valley floor was lowered about 20 ft. Cold climate.
5. Flood Plain Terrace. Third stage of deposition; gravel, sand and brick-earth.
6. Third stage of corrosion, with a further deepening of the valley; amount not ascertainable in this area.

The last-mentioned stage appears to have been arrested by a subsidence of the land, of which there is evidence in the lower reaches of the Thames, but of which no indication has been found in the present map. The deposition of the modern alluvium in the area under description succeeded, and perhaps in part accompanied this subsidence.

BOYN HILL GRAVELS.

The Boyn Hill Terrace of the Thames itself is but sparingly represented in this area, being developed only at Maidenhead Golf Course and in the neighbourhood of West Drayton. Its position at these places and in the country to the north (Sheet 255) suggests that at the time of its deposition, the Thames and its tributaries occupied courses diverging widely from their present arrangement, the Thames at that time probably flowing approximately from west to east along the northern margin of the area shown on the map, instead of taking the present great southerly bend past Chertsey and Walton, while the lower courses of the Wey, the Mole and the smaller streams joining the Thames on the right or southern bank, were by so much the longer than at present, and on the other hand that of the Colne flowing from the north was proportionately shorter. The fuller evidence for these changes is given on pp. 86-89.

Near Maidenhead, the only locality within the area under description where the outer margin of this terrace is seen, the gravels cap the highest ground, and there is no indication of a shelf of erosion cut in the side of the valley; but a margin of this kind does occur at Burnham (Sheet 255), a little beyond the north edge of the present map.

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[1] Treacher, Ll. 'Palaeolithic Man in E. Berks.' *Berks, Bucks and Oxon. Archæol. Journ.*, vol. ii, 1896, p. 17.

[2] See Smith, R.A., and H. Dewey. 'Stratification at Swanscombe.' *Archæologia*, vol. lxiv, 1913, pp. 177-204.

[3] Smith, R. A. *Archæologia*, vol. lxii, 1911, p. 532.

In the south-eastern part of the area the Boyn Hill Terrace is better developed, but as already pointed out by Mr. Monckton,[1] its gravels belong to the drainage systems of the Wey and Mole rather than to the Thames itself.

Composition of the Gravels.—There are marked differences in the materials of the gravels belonging to the Thames, and those belonging to its southern tributaries. The Thames gravels consist mainly of slightly worn flints together with flint-pebbles and sarsen-stone from the Tertiary beds, red and grey Bunter quartzites and vein-quartz, masses of chalk and fresh flints, fossils, and other debris from the Jurassic rocks, and a few other ingredients. The gravels belonging to the southern tributaries contain stones derived from the solid rocks or plateau gravels of the area they drain; there is usually a high proportion of sand derived mainly from the Bagshot Series; in many instances the river deposit consists almost entirely of sand, and in the absence of good sections is difficult to distinguish from Bagshot Beds in place. Other constituents are flint-pebbles, Lower Greensand chert, subangular flints, and ironstone from the Folkstone and other beds. The cherts are frequently found in large angular masses with the fresh, resinous appearance of the rock as it occurs *in situ* about Leith Hill; smaller rounded fragments are common, but are generally spongy and more or less decomposed. These southern gravels never contain Bunter pebbles.

No contemporaneous fossils have been found in the gravels of this terrace within the limit of the present map, but several flint implements have been obtained from the gravels of the Maidenhead Golf Course. Their more frequent occurrence at the pits of the type locality, Boyn Hill,[2] has already been referred to, and a fuller description will be given in the Memoir on the area (Sheet 255) within which they occur.

C. N. B.

Local Details.

BOYN HILL GRAVELS OF THE THAMES.

On the right bank of the Thames, where it enters the map, there is a single patch of these gravels forming the high plateau round Shoppenhanger's Farm, now the site of the Maidenhead Golf Links. Numerous pits have been opened here, and several are still worked. The largest, known as King's Pit, lying immediately south of the railway and west of the road to Shoppenhanger's Farm, shows a face about 10 ft. in height composed of coarse and fine gravel in well stratified bands with occasional lenticles of fine yellow sand. Here Mr. Treacher has obtained five flint implements; they include ovate and triangular forms, all coarsely worked and more or less abraded, belonging to the Chelles type. A block of quartz-conglomerate measuring about 6 by 2½ ins. has been recorded,[3] and we noted smaller pebbles of the same material. Another pit just north of Kimber's House shows 8 ft. of gravel, unusually well stratified but containing less sand than the last. Quartz and quartzite pebbles are comparatively abundant, together with small fragments of Chalk and pieces of *Inoceramus* shell. In all these gravels flint casts of echinoderms occur frequently. South of the copse on the eastern flank of the hill a disused pit showed nearly 20 ft. of gravel, strongly ironshot, and appreciably more sandy towards the base; the great thickness here, compared with other sections, may be due in part to hillcreep. Just north of Shoppenhanger's Farm water stands in the bottom of a pit only 6 ft. in depth, apparently held up by the Reading Beds immediately beneath the pit floor. In the railway cutting the margin of the gravel is seen resting directly on the Chalk, as is probably the case also at King's Pit, but further south the Reading Clays intervene, in consequence of which a small but constant supply of water is obtained from the gravel. The surface of the gravels is at about 140 ft. O.D.

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[1] 'Excursions to Farnham and Dawley.' *Proc. Geol. Assoc.*, vol. xviii, 1904, p. 414.

[2] Ll. Treacher. 'Palaeolithic Man in East Berks.'' *Berks, Bucks and Oxon. Archæol. Journ.*, vol. ii, 1896, p. 17.

[3] Monckton, H. W. *Quart. Journ. Geol. Soc.*, vol. xlix, 1893, p. 315.

On the opposite, or left side of the river, the Boyn Hill Terrace lies for the most part in the map to the north (Sheet 255), but small spurs project into the present area, one between Langley and West Drayton, another just east of the latter place. The first of these, north of Thorney House, is isolated from the Taplow Terrace by an outcrop of bare London Clay. At a pit between the railway and the canal Mr. Howe noted 15 ft. of well-bedded sandy gravel with a few thin layers of loamy sand beneath 4 ft. of brick-earth; a similar section is exposed in the canal cutting.

East of the Colne the division between the Boyn Hill and Taplow Terraces is frequently obscure. We know that there is a definite shelf cut in the London Clay, but frequently the upper gravels have to some extent been washed over this, and the brick-earth of the Taplow Stage overlaps on to the Boyn Hill gravels. North of Starvhall Farm the Boyn Hill gravel emerges from beneath the brick-earth, and a small pit on the north bank of the canal just west of the road-bridge reveals the London Clay within 3 ft. of the surface. At a pit a quarter of a mile to the north, just outside the map, Mr. Howe noted 10 ft. of brick-earth over 15 ft. of gravel. The same distance to the east of the former place is the Great Dawley gravel pit, showing fully 20 ft. of gravel beneath brick-earth; to the south also these deposits are of considerable thickness; the exact position of the base of the gravel is concealed by the newer brick-earth, which completely covers the margin of the terrace. C. N. B.

BOYN HILL GRAVELS OF THE TRIBUTARY STREAMS.

Near the south-western corner of the map several small tracts of gravel are shown to the east of Barossa Farm. These form part of a series described by Prof. Rupert Jones[1] and ascribed to the highest (Boyn Hill) terrace, which he traced from the Thames, through the Loddon Valley, into that of the Blackwater. Besides these, it is possible that the sheets of gravel between Sandhurst and Edgbarrow Hill may also belong to the Boyn Hill period, though it was thought safer to class them with Plateau Gravel on the map (see p. 66).

Chertsey Bourne.—As there are two streams named the Bourne on the map, the one which drains Virginia Water and flows past Chertsey will be distinguished as the Chertsey Bourne, the other, which rises near Ascot and flows through Addlestone will be referred to as the Hale Bourne, the name given to it on the map in part of its course.

The upper waters of the streams round Virginia Water drain an area much of which is covered by thin spreads of sand and pebbles: it is not impossible that some of these may be of Boyn Hill age, but as they cannot be definitely connected with the present drainage system, the whole have been included with the Plateau Gravels (see above, p. 65).

The large sheet of gravel on the north side of the stream stretching from the lake to Virginia Water Station, and several smaller patches on the south side have been classed as Boyn Hill; they lie nearly 80 ft. below those shown as Plateau Gravel in the immediate vicinity. A small pit near Wentworth showed 4 ft. of current-bedded sandy gravel with much chert and vein-quartz, the top part being contorted. Towards the station this deposit overlies and is difficult to separate from the Bagshot pebble-bed. The next occurrence, north of Trumps Farm, may be claimed as belonging to the present Chertsey Bourne drainage, but beyond this the gravels of Boyn Hill age fringe an older course[1] which passes to the south of Chertsey, as described on p. 90. H. D.

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[1] 'Geology of the Bagshot District.' *Proc. Geol. Assoc.*, vol. vi, 1879, p. 429.

Following this older course these gravels cap the hill at Lynegrove. On the eastern margin of the Park are some small pits reaching a depth of about 4 ft. The gravel contains seams of glauconitic clayey sands, evidently derived from the Bracklesham Beds, a small outlier of which is preserved beneath the eastern end of the gravels. Banded chert of resinous texture is abundant in masses up to 6 ins. in length, spongy chert usually as pebbles not exceeding 2 ins. in diameter, many flint pebbles and slightly worn flints, and ironstone being the chief constituents; quartz pebbles are frequent, but never exceed ½ in. in diameter; one block of sarsen stone was seen measuring rather more than 9 ins. by 4 ins.

North of the old course small patches of this gravel have been mapped near the Hollies, on Cockcrow Hill, by Sandgates, and on Woburn Hill; on the south side there are more extensive tracts in Silverlands and Botleys Park, continuing round the flank of the hill to Coombelands Park. There are no sections of importance, but sufficient evidence to show that the character of the gravel remains constant and its thickness 4 to 6 ft. Above Coombelands, in the valley of the Hale Bourne, some small patches of gravel lying to the north of Dunford Bridge at about 130 ft. O.D. are probably of Boyn Hill age.

New Zealand and Scotland.—South of the Hale Bourne there is a considerable spread of these gravels to the west of Woodham Lodge. Although now near this stream, the gravels appear to belong to the Wey drainage, for they must have once joined on to another large patch, further south, which clearly belongs to this river. This interpretation is confirmed by the occurrence in the gravels of numerous large fragments of fresh chert, which do not occur in the Hale Bourne gravels. Their occurrence in this position is due to the Wey having shifted its course eastward, with the result that this mass has been left on the west side, while the corresponding deposit on the east bank has been removed. The gravel is not now worked, but in temporary sections has been noted to a depth of 8 ft.

East of the Wey.—There is a wide spread of Boyn Hill gravel on and around Walton Common; as pointed out by Mr. Monckton,[2] this is essentially a gravel of the Mole, though it is not improbable that the western part was contributed by the Wey.

In consequence of its comparative thickness this gravel has been dug to a large extent. The section in the South-Western Railway cutting is now largely obscured, but was described, when the line was widened, by Hudleston. In his description he uses the term 'Plateau Gravel' and remarks that 'the materials are similar to those of sheets occurring at much higher levels, such as the one on St. George's Hill; and, although at so low an elevation, appears to have nothing in common with the valley-gravels of the district.'[3] At the same time he evidently recognised that a connection with the present drainage was discernible (*ibid.* p. 538). The gravels rest on an irregular surface of London Clay and vary in thickness from 8 to 24 ft.; the lower part is usually 'cemented by deep brick-red iron-oxide with here and there a streak of black oxide of manganese above.'[4] 'Pebbles and regular bedding predominate in the lower portions; the upper part . . contains more angular flints, and is on the whole more sandy' (*ibid.* p. 156).

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[1] See 'Summary of Progress for 1911.' *Mem. Geol. Surv.*, 1912, Appendix II.

[2] *Proc. Geol. Assoc.*, vol. xviii, 1904, p. 414.

[3] *Proc. Geol. Assoc.*, vol. ix, 1886, p. 540.

[4] *Quart. Journ. Geol. Soc.*, vol. xlii, 1886, p. 164.

By the southern margin of Walton Common there are several large pits, now for the most part disused; the thickness of the gravel does not appear to exceed 12 ft.

Further to the south there are several small patches of gravel situated on the flank of St. George's Hill, evidently the remains of the Boyn Hill terrace of the Mole. In one of these, close to Burwood House, a small pit showed 10 ft. of coarse gravel containing large flints and cherts. There are many other small pits where gravel has been dug for local purposes, but most of them are now obscured.

C. N. B.

TAPLOW GRAVELS.

In character and composition the gravels of the Taplow Terrace do not differ materially from those of the Boyn Hill Terrace, except that possibly Jurassic fragments are slightly more abundant; they are well displayed at Taplow, a little to the north of the present map, the pits being on the north side of the Great Western Railway station. A detailed account of these sections will be given in the Memoir on that district (Sheet 255), but it may be mentioned that they have there yielded remains of Musk Ox, *Elephas primigenius*, *Rhinoceras tichorhinus*, etc.[1] Implements are by no means common, and those that have been found are waterworn and probably derived from the Boyn gravels. Similar abraded specimens have been found to the east of Taplow, and it is not till Dawley is reached that unworn implements, properly belonging to the Taplow Terrace, are met with. At this locality Allen-Brown found fresh unabraded implements which 'may be classed with the long flake-formed implements of the oldest cave of the Dordogne, that of Le Moustier.'[2] There is no record of implements having been found in the gravels of this age in the tributary rivers of the district. The evidence of the organic remains and of the implements combines, therefore, to show that the Taplow Terrace is mainly of Mousterian age.

At the close of the Boyn Hill stage the gravels deposited by the river rested directly on soft Tertiary strata, and were in contact with them on both sides of the valley. As these gravels are more difficult to erode than the Tertiary Beds there was a constant tendency, when corrosion was resumed, for the river to deepen its channel by cutting into the marginal soft beds, thus shifting its course. In the present area the Thames seems generally to have hugged the southern margin of its valley, and has tended to shift its bed steadily in that direction. This southward shift is most marked in the eastern part of the district, and seems to be due to the influence of the Colne. Throughout the Taplow stage that river was bringing down vast quantities of coarse gravel from the fluvio-glacial deposits occurring higher up its valley, and these, being deposited where it entered the main valley, pushed the Thames further and further south. The great bend by Chertsey and Weybridge was thus initiated.

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[1] Owen, Prof. R. 'Fossil Musk-Buffalo.' *Quart. Journ. Geol. Soc.*, vol. xii, 1856, pp. 124-130. Dawkins, Prof. W. B. 'British Post-glacial Mammals.' ibid. vol. xxv, 1869, p. 198.

[2] 'High Level River Drift between Hanwell and Iver.' *Proc. Geol. Assoc.*, vol. xiv, 1896, p. 164.

The higher or outer margin of the Taplow Terrace of the Thames formed at the commencement of the stage does not markedly diverge from a general parallelism with the Boyn Terrace; but as erosion proceeded and its lower margin moved southward, it diverged more and more from the Boyn Terrace, until locally the two directions are almost at right angles.

On the west or right bank of the river about Bray, near the point where the Thames first enters the map, there is the full succession of the Boyn Hill Terrace capping a steep slope, almost a cliff, of chalk and soft Tertiary Beds, with the Taplow Terrace at its foot. Further down the river, on this side, the Taplow Terrace probably lies to the south of any position formerly occupied by the Boyn Hill Terrace. On the north side of the river a large part of the earlier terrace still remains, though the Taplow shelf grows steadily broader. Its outer margin on this side is always higher than the corresponding margin on the south, and rests at a higher level on the Tertiary Beds, indicating that the gravels on this north side were deposited slightly earlier in Taplow times. This difference in height between the northern and southern margin of the terrace is specially marked in the eastern part of the district, where the gravels brought down by the Colne enter the Thames valley. Here the upper limit is slightly above 100 ft., a fact which has led some observers to describe these deposits as a part of the '100-Ft. Terrace,' and so confuse them with the Boyn Hill gravels. The greater local height is possibly due to this portion of the terrace being in part a fan thrown out from the tributary Colne valley.

C. N. B.

LOCAL DETAILS.

TAPLOW GRAVELS OF THAMES.

On the right or west bank of the Thames a strip of Taplow gravel enters the area from Maidenhead and runs through Braywick to Oakley. There is a sharp rise from the alluvium to the surface of the terrace, which is mostly about 85 to 90 O.D. To the north of Braywick the upper margin is marked by a cliff of Chalk and Reading Beds surmounted by the Boyn Hill gravels; but from Holyport to Oakley 'the boundary line is somewhat doubtful, as the Tertiary Beds for the most part rise at once from beneath the gravel, but for some distance form a flat continuous with it.'[1] Along the main road between Maidenhead and Windsor the gravel has been dug from several pits, but most of these are now obscured. The pit marked on the map opposite the grounds of Cannon Hill still shows 7 ft. of well-stratified gravel with thin lenticles of sand; and another, a quarter of a mile to the west, 10 ft. of gravel underlying 9 ins. of loamy sand: here quartz pebbles occur up to 10 ins. in diameter. A well at Oakley Court showed 19 ft. of this gravel lying on London Clay.

On the north side of the river the Taplow Terrace enters the map from the north at Cippenham, and widens eastwards, its southern margin foreshadowing the bend of the present course.

In a pit at Cippenham, just on the north margin of the map, worked by the Eton Urban District Council for road-metal, 12 ft. of gravel with current-bedded seams of sand and sandy clay, is overlain at one corner by a foot or two of brick-earth. The workmen say that poor implements are occasionally found, a specimen we saw being clearly one of the usual water-worn Chellean hand-axes derived from a higher terrace; they also said that some mammoth teeth came to light two years before our visit (*i.e.*, in 1908). We noted a sarsen stone measuring 5 by 5 by 2 ft.

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[1] Whitaker, W. 'Geology of London.' *Mem. Geol. Surv.*, vol. i, 1889, p. 390.

Between Chalvey and Salt Hill, a large pit, now practically disused, showed 11 ft. of gravel resting on Reading Clays; a molar of mammoth in the Royal Albert Institute Museum at Windsor, labelled Chalvey, probably came from this exposure.

At Slough the gravel is concealed by a considerable thickness of brick-earth (see p. 80), but was proved in Horlick's well, nearly ½ mile west of the station, to be 24 ft. thick.

Round Langley also the gravels are concealed by brick-earth, though there are a few small pits beside the Bath Road; Evans[1] records Palaeoliths from this locality.

Crossing the Colne we find several extensive pits by West Drayton and Dawley. These have been described by Allen Brown in several papers; he speaks of the 'Upper Terraces,' and appears to have considered that it was the equivalent of the '100-ft. (Boyn Hill) terrace' of the Lower Thames, since the surface of its upper margin rises slightly above the 100-ft. contour; we have already (p. 73) stated our reasons for disagreeing with this correlation. Further to the east (in Sheet 270), by Southall, Ealing and Acton, the same writer records mammoth remains and Mousterian implements at levels between 80 and 100 feet.[2] He considers that in this district only the lower part of the gravel is of strictly fluviatile origin; the upper part, which is certainly less obviously stratified, he regards as 'the result of the intrusion of masses of frozen material, or a minor form of morainic deposit brought by ice from higher ground, it may be, at successive periods, into the bed of the old river represented by the lower or stratified deposits beneath, indicating very cold climatic conditions in winter, and a short warm summer, when the ice which cemented such varied deposits together melted, leaving most of the masses as we find them, but sometimes allowing of their being broken up and dispersed by the flowing river. The eroded surface of the lower bed would lead to the inference that it was, for a time at least, above water, and, probably, inhabited by men, until it was again invaded by ice-borne matter or Fluvio-Glacial Drift.'[3] These conclusions, however, may require some modification.

There are indications of a cold climate during the stage following that of the Taplow Terrace. The effects are recognisable in all deposits older than the Flood-plain gravels, both in the form of contortions and puckerings of the surface layers to a depth of about 6 ft., and in the development of soil-creep (p. 81). Indeed, to soil-creep most of the phenomena in question may be attributed. For example, the northern margin of the Taplow Terrace at Dawley is separated from the lower margin of the Boyn Hill Terrace by a narrow slope of clay. During the cold stage the Boyn Hill gravel crept down the slope and buried the tract on which Mousterian man had his settlements. Most of the pits in this neighbourhood have been closed for many years; Allen Brown's descriptions of the chief sections are as follows:—At West Drayton 'the sections show . deposits of generally unstratified and contorted gravel, with enclosures of sand, very pebbly gravel, bluish and brown clay . . . above a stratified bed, and beneath brick-earth and trail. . . Many of the large number of flint implements found in the pits at West Drayton, as well as at Dawley, are very much abraded, and, in many cases, the angles of chipping are half obliterated. There are many others, however, in my collection from these large excavations, which have not suffered at all from rolling, while others are slightly abraded.'[1] 'A number of Palaeolithic implements . . . . . consisting of long, sharp spear-heads, knives, &c., wrought into shape by secondary chipping, have been discovered nearer the surface than the ordinary implements formed from nodules. They are generally found at depths varying from 5 to 10 ft., and beneath the unstratified deposit. They are often nearly 6 in. in length, and are as sharp and unabraded as if they were made yesterday; they vary in colour externally and are lustrous. As mentioned elsewhere, they probably belong to the same age as those found at the late Palaeolithic workshop floor at Acton, which they greatly resemble, and may be classed with the long flake-formed implements of the oldest cave in the Dordogne, that of Le Moustier' (*ibid.* pp. 163 and 164). In this paper the author figures the sections at Eastwood's and Pipkin's pits, both at West Drayton. Between here and Hayes station there are several more exposures of which he gives detailed descriptions, but they are in the main similar to the above.[2]

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[1] 'Ancient Stone Implements.' Ed. 2, 8vo, London, 1897, p. 591.

[2] See 'Surface Deposits of the Ealing District.' *Quart. Journ. Geol. Soc.*, vol. xlii, 1886, pp. 192-200; 'Palaeolithic Period in the Thames Valley.' *Trans. Middlesex Nat. Hist. and Sci. Soc.*, 1888-9, p. 64; 'Discovery of *Elephas primigenius* at Southall.' *Proc. Geol. Assoc.*, vol. x, 1889, pp. 361-372.

[3] *Proc. Geol. Assoc.*, vol. xiv, 1896, p. 162.

'Among the many flint implements which have been found in the pits at Dawley, there are some which should be specially mentioned, foremost among which is one of a flattened pear shape, about 4½ by 3½ in. of Felsite or Eurite with black spots of Riebeckite. . . . It is in my collection, with others from the same pits, which are of unusual interest. One is an almost unabraded flint implement nearly unique as to its perfect form and preservation; it is 7½ in. in length by 5¼ wide at the butt. . . . This and many others were found during a number of years in the stratified bed, 15 to 16 ft. from the surface, as were also some flakes scratched or striated on the flat side. Three well-preserved casts of *Rhynchonella* were discovered close together in this pit' (*ibid.* pp. 159 and 160). He also mentions the occurrence of the usual abraded implement derived from older deposits.[3]

The lower ground to the south is not so favourable for working, as the water-level is never far below the surface; accordingly exposures are few and unimportant. Near the Bath Road between Longford and Cranford several disused pits show 1 to 4 ft. of soil over gravel with water standing about 8 ft. below the surface. At Staines Reservoir, examined by Mr. T. I. Pocock during its construction, the little cliff of London Clay between the middle and low terraces was well developed: at the northern side the gravel was 12 to 13 ft. thick. Further east the division between the Boyn Hill and Taplow Terraces is somewhat vague up to the point where it passes beyond the limits of the map under description.

TAPLOW GRAVELS OF THE TRIBUTARY STREAMS.

Of the Taplow deposits of the tributary valleys there is comparatively little to be said.

In the basin of the Blackwater, the gravels situated between Nine Mile Ride and Wokingham may perhaps represent the Taplow Terrace of a small feeder of that river.

The Chertsey Bourne has a band of gravels of this stage extending from Virginia Water to Addlestone, the greater part lying in the abandoned valley south of St. Ann's Hill. To the west of the railway at Virginia Water the terrace is only a few feet above the present stream, whose alluvium is in contact with the gravels. Further down by the mill, the diversion of the stream has given it a quicker fall and enabled it to deepen its valley. On the north side there are patches of Taplow gravel separated from the stream by a little cliff of Bagshot sand; on the south the slope is less steep and is covered by a deposit of peat. A small disused pit shows about 6 ft. of coarse sandy gravel. Flint pebbles are the dominant constituent, after which in the order of their relative abundance come Greensand chert, slightly worn flints, ironstone, sarsen, and small quartz pebbles. By The Almners there is a wide spread of gravel which has been dug in several large pits; the only one now working shows about 5 ft. of gravel, similar to that just described, overlying Bagshot Sand; some lenticles of sand in the gravel are here and there highly glauconitic and apparently derived from the Bracklesham series; sarsens are occasionally found at the base of the gravel. North of the copse the gravel is overlain by peat.

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[1] *Proc. Geol. Assoc.*, vol. xiv, 1896, p. 162.

[2] See also *Ibid.*, 'Excursion to Hanwell, Dawley, and West Drayton,' pp. 118-120.

[3] 'Palaeolithic Man in N.W. Middlesex,' London, 1887, pp. 62 and 92.

Addlestone is built upon an expanse of Taplow gravel lying between the old course of the Chertsey and that of the Hale Bourne. In the latter there are some patches of gravel which may be referable to the Taplow Terrace; they are not of sufficient thickness to be worked, and are very sandy.

The Taplow gravels of the Wey form a large expanse by Byfleet and Newhaw, having a gradual slope from the western margin towards the river, where the lower limit is slightly below the 50-ft. contour. At the time of the recent survey water mains were being laid down in this ground, and gravel was exposed to a depth of 8 ft. without its base being touched. In many places the deposit consists almost entirely of sand, but here and there are seams of flints with occasional cherts. Teeth of mammoth are said to have been found here.

The upper part of Weybridge is built upon the Taplow gravels of the Wey. The terrace slopes down to the Flood-plain of the Thames but is separated from the Boyn Hill Terrace by an outcrop of Bagshot Sands.

The Taplow gravels of the Mole occupy a small area on the eastern margin of the map; they include those at Walton, where the Thames has cut into them producing a well-marked cliff with London Clay exposed in the lower part. That the deposit belongs to the Mole and not to the Thames is indicated by its composition, which is mainly sand with occasional flint pebbles and subangular flints; quartzite, quartz, &c. are entirely absent. There is a small outlier of the Taplow Terrace in Burhill Park and another at Burwood. On the eastern side of the Mole the surface of the terrace lies 12 to 15 ft. above the alluvium; its upper part there is almost entirely sand, but below 3 ft. it becomes more stony.

C. N. B.

FLOOD-PLAIN GRAVELS.

Under the term 'Flood-plain gravels' are included all the river gravels younger than those of the Taplow Terrace; their accumulation continued until the Recent alluvium began to be deposited, and that they cover a long period is shown by the changes in the fauna, the progress of human industry, and by the sequence of events which can be made out in the Lower Thames Valley during this stage. The evidence for the physical changes during the period is found chiefly in the lower reaches of the Thames, and only to a minor degree within the present district. But the presence of 33 ft. of Flood-plain gravel at Chertsey shows that at some time during the period the river had cut its bed to considerably below its present level, and subsequently filled up this channel to the height of its present bed.

The close of the Taplow period was marked by a lowering of the valley-floor by corrosion, to the extent of about 15 ft. During this period of corrosion there were important changes in the fauna of the district, so that by the time that the earlier of the Flood-plain gravels were deposited, several new mammals had been introduced, including the ox and the Saiga antelope, while the characteristic mammal, the reindeer, already present towards the end of the Taplow period, now became abundant. On the continent this animal reached its acme during Upper Palaeolithic times, which are therefore known as 'L'age du Renne.' The only surviving elephant, the mammoth, had become rare, and with it are lost the other members of the cold fauna abundant in the previous epoch.

Of the progress of human culture during the period of the Flood-plain gravels there is practically no evidence within the present district, but at Uxbridge, a few miles to the north, a large number of implements of Magdalenian type have been found lying on the top of these gravels beneath the recent alluvium.[1] The gravels must therefore have been laid down before that period. It has been shown that the Taplow Terrace is roughly of Mousterian age; the Aurignacian and Solutrian phases of culture must accordingly fall within the time represented by the succeeding stages of erosion along with that of the deposition of the Flood-plain Terrace, but as yet no implements belonging to these periods have been found in the deposits.

It was at this period that the Thames attained its maximum deflection towards the south. From a mile or two above Windsor to Chertsey the flood-plain is bounded by a cliff of the solid strata showing that the river was widening the valley beyond its former limits on this side. To-day the river meanders on the surface of the plain thus formed, and nowhere touches its old cliff, except perhaps for half a mile just below Walton Bridge. The valley of the Flood-plain gravels is therefore still preserved to its full width, the original left bank being marked out by the edge of the Taplow Terrace, while the right bank is formed by the same terrace at Bray and Oakley, and by the cliff of solid rock from that point to Walton, with breaks on both sides where the various tributaries enter. Its narrowest point is at Windsor, where it is only 1¼ miles, whereas between Stanwell and Weybridge it is fully 5 miles in width. Even where of this width the Flood-plain Terrace has a fall not exceeding 15 ft. between its outer and inner margins; it thus differs greatly from the Taplow Terrace, in which the difference of level between the corresponding points is fully 50 ft. Practically all the gravel of the Flood-plain stage shown on the map belongs to the Thames itself. In the tributary valleys gravels usually underlie the alluvium, and only here and there rise above it in the form of small islands.

The composition of the gravels is similar to that of the other Thames gravels, the presence of red and grey quartzite serving to distinguish it from the deposits of the southern tributary streams.

The Flood-plain gravels owing to their slight elevation above the existing river always contain water, and in times of flood the water-level rises above their surface, so that large areas become submerged before the river overflows the retaining banks. Sections of the gravels are therefore scarce, and for details we are mainly dependent on records of trial borings and temporary excavations.

C. N. B.

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[1] Hinton, M. A. C., and A. S. Kennard. 'Relative Ages of Stone Implements of Lower Thames Valley.' *Proc. Geol. Assoc.*, vol. xix, 1906, pp. 95 and 96.

LOCAL DETAILS.

Where it enters the map from the north the Flood-plain gravel forms a broad stretch on the left bank, but on the right is separated from the Taplow terrace by a channel filled with alluvium, the village of Bray being built upon an island of it. This channel, apparently an old backwater of the Thames, is blocked at its mouth opposite Queen's Ayot by another little island of gravel; a small pit here showed 4 ft. of somewhat fine sandy gravel. Gravel dredged from the bed of the Thames at this point, presumably the lower part of the same deposit, is much coarser; many of its constituent pebbles are coated with carbonate of lime, the 'Thames Mark' familiar to London antiquaries.

On the Buckinghamshire side, between Burnham Abbey and Cippenham, the gravel is overlain by a small patch of Brick-earth; and between Dorney and Datchet irregular channels cut in the gravel are partially filled with alluvium. There are occasional shallow pits where the gravel has been worked, but they show no special features. The full thickness of the gravel at Burnham Abbey is probably indicated by a well 15 ft. deep. Between Dorney and Eton Wick a trial boring on the alluvium showed 27 ft. of sand and gravel above the London Clay.

Clewer and the lower part of Windsor are built on Flood-plain gravels. In 1867 Mr. Whitaker saw 'a pit 17 ft. deep, in rather fine sandy gravel' where the Windsor Infantry Barracks now stand.[1] At a depth of about 9 ft. from the surface a large number of mammalian bones were found: of these Prof. Boyd Dawkins writes, 'I found more than one-half of these remains belonged to the reindeer, the rest to bisons, horses, wolves, and bears.'[2] At Canning's Brewery, in Peascod Street, when a well was sunk, 'the hard bed gravel was cut through at a depth of 18 ft., in which were found bones of the reindeer, and bones and horns of other animals. One horn was hatched, showing grooves of a saw or of a similar instrument.'[3]

The above records suggest to Prof. Boyd Dawkins the existence near this place of an ancient 'Reindeer ford' across the Thames: 'We may infer that a Palaeolithic hunter, standing on one of the hills commanding a view of the district above Windsor in winter time would have seen vast herds of reindeer crossing the stream, and in the summer herds of horses and bisons availing themselves of the same fords with wolves and bears in their train' (*op. cit.*, p. 156).

At Frogmore, in the Home Park of Windsor Castle 'a fragment of a leg-bone of an Elephant, another of Bos (?), a broken horn-core of Bos, and an antler of *Cervus intermedius* (?)' were found shortly before 1860 at a depth of 15 ft. in clean gravel beneath 6 or 7 ft. of red gravel and 4 or 5 ft. of sandy loam.[4]

Near Old Windsor Lock a trial boring put down in 1871 showed gravel to a depth of 20 ft. On the northern side, Eton, Datchet, Horton, and Wyrardisbury (Wraysbury), are built on Flood-plain gravels. At Slough Waterworks, Datchet, the thickness of these deposits was 11 ft. 6 ins., at Ditton Park, 10 ft.; at Ankerwyke, 27 ft.; at Horton, 22 ft. Near the smithy at Wyrardisbury a small pit showed 5½ ft. of gravel and sand, with a 3-in. iron pan 1½ ft. below the surface.

On the long 'island,' lying between the Colne Brook and the Wyrardisbury River, on which Runnymede ranges are situated, the gravel is about 25 ft. thick.

Below the confluence of the Colne there is a wide spread of Flood-plain gravel on each side of the Thames. On the right bank Egham and Thorpe are built upon it, the old part of Chertsey being upon an 'island' of the same. At Egham Waterworks the well-section showed 23 ft. of sand and gravel, with a bed of large stones at the base; at Chertsey the thickness of the soil and gravel amounted to 33 ft. On the east side of Egham the gravel is overlain by a small patch of brick-earth.

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[1] 'Geology of London.' *Mem. Geol. Surv.*, vol. i, 1889, p. 392.

[2] 'Early Man in Britain.' 8vo, London, 1880, p. 155.

[3] *Proc. Windsor and Eton Sci. Soc.* for 1886, Windsor, 1887, p. 15.

[4] 'Fossil Bones at Frogmore.' *The Geologist*, vol. iii, 1860, p. 420.

On the Middlesex side there are a number of patches of similar Brick-earth (see p. 80). At Staines Reservoir the thickness of the gravel overlying the London Clay was 12 to 18 ft. (see p. 75), and at the West Bedfont Waterworks the section seen by Mr. Pocock in 1902 was:—Soil and gravel, 4 ft.; loamy clay holding up water, 2 to 3 ft.; gravel, sandy at bottom, 12 ft., resting on London Clay.

Round Ashford and Feltham there are many shallow pits, but all are now disused. The following thicknesses are taken from records of borings:—Staines (average thickness), 23 ft.; Staines Union, 20 ft.; Knowle Green, 18 ft.; Ashford Manor Farm, 20 ft.; Laleham, 29 ft.; Littleton House, 30 ft.; near Ashford Lodge, 20 ft.; Charlton, 15 ft.; and Sunbury, 13½ ft.

In the valley of the Blackwater there are gravels of this stage on each side of the river, but no sections; the lower part of the village of Sandhurst is built upon them.

The gravels along the Binfield Brook, noted by Mr. Monckton,[1] rise little above the average water level. Between Warfield and West End a section in the bank showed about 2 ft. of sandy gravel containing chert, flints, and flint pebbles, overlain by 18 ins. of rearranged London Clay. North of Binfield Village the only pits open at the time of the recent survey are on the eastern bank of the stream opposite Hill Farm. Here about 4 ft. of sandy gravel, resting on London Clay, consists mainly of Greensand chert, with the usual flints and flint pebbles, and quartz up to half an inch in diameter.

C. N. B.

BRICK-EARTH.

The brick-earth of this part of the Thames valley is a stoneless loam, and was formerly of considerable economic importance, but a large part of that which is of sufficient thickness to be worked has already been exhausted. Implements and fossils have seldom been found in it, though Mr. Sadler, of Acton, has obtained Mousterian implements from the Middle Terrace Brick-earths of Hanwell in Sheet 270, three miles east of this district. In describing the Brick-earth in his paper on the 'Thames Valley Drifts,' Mr. Pocock writes: 'In Middlesex it . . . . covers indifferently all the three terraces. Professor Prestwich long ago compared the brick-earth to the Loëss of the Rhine Valley[2] and other parts of Central Europe. Like that deposit, it owes its origin to different agencies, and probably also to varying conditions of climate and geography extending over a considerable space of time. Moreover, it belongs to more than one distinct epoch. Some of the deposits may be older than the middle [*i.e.*, Taplow] terrace. Others are younger than the later [Flood-plain] terrace, for they form thin sheets covering the lowest gravel near the river in Middlesex, and probably pass up the slopes over the older brick-earths. Sections of this later brick-earth can be seen near Shepperton Railway Station and at the Brick Works, Upper Halliford.'[3]

The material has probably been derived mainly from the London Clay, from which it would be difficult, but for its position, to distinguish it. Much of it may have been laid down as an alluvial deposit of the flood-waters of the Thames when the respective gravel terraces on which it rests formed the flood-plain. This view is supported by the fact that the principal deposits of brick-earth are found below Windsor, where, as stated below (p. 87), the various terraces in passing down the valley lose their previously rather high gradients, and become nearly flat.

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[1] *Quart. Journ. Geol. Soc.*, vol. xlix, 1893, p. 316.

[2] 'The Loëss of the South of England.' *Phil. Trans. Roy. Soc.*, vol. cliv, 1865, pp. 247-309.

[3] 'Summary of Progress for 1902.' *Mem. Geol. Surv.*, 1903, Appendix VIII, pp. 204-5.

The main mass of the brick-earth shown on the map lies on gravels belonging to the Taplow Terrace. There is a small patch between Langley and West Drayton which rests on Boyn Hill gravels, and may belong to that terrace. On the Flood-plain we find several small areas covered with brick-earth. The junction of the brick-earth with the underlying gravel is always sharply defined.

C. N. B.

LOCAL DETAILS.

North of Thorney, on the west bank of the Colne, the brick-earth resting on the Boyn Hill Terrace has mostly been removed. In 1902, Mr. Howe noted a face 5 to 8 ft. in height of good clean brick-earth in Reed's yard, but this lies just beyond the northern margin of the map. Southwards as far as the canal all the brick-earth has been used, while between the canal and the railway its thickness is not greater than 2½ ft., and it thins out altogether just south of the railway.

The brick-earth which belongs unquestionably to the Taplow Terrace is of greater extent and importance. The most westerly occurrence is a small tongue extending into the area from the north between Cippenham and Salt Hill. In a gravel pit on the north side of the main road, 2 to 6 ft. of brick-earth was noted, but the extent of the deposit is too small to be of economic value.

Round Slough and Langley there is a wide expanse of fairly thick brick-earth, much of which is being worked. In the cutting by the junction of the main and Windsor lines of the Great Western Railway there appears to be 8 or 10 ft. of clean brick-earth, and in the large brickworks north of Slough Station the thickness varies from 3 to 9 ft. The material worked here is a typical reddish-brown brick-earth, showing no structure and resting with a sharp junction on a fairly even surface of gravels. Both red and stock bricks are made, but no tiles. Further east by Middle Green are many former brickfields, all now abandoned, the workable material having been cleared off wherever accessible, leaving the gravel exposed at the surface. Immediately north of Langley Station, Mr. Howe, in 1902, noted a face showing: Soil, 8 ins.; dark brick-earth, 3 ft.; paler brick-earth (seen), 1 ft. Where not obscured the sections in the canal bank appear to be similar.

East of the Colne, round West Drayton and Harlington, a large area was formerly covered by brick-earth, now almost completely removed. It appears to have been about 6 to 8 ft. in thickness, thinning against the spur of Boyn Hill gravels on the north and at Harmondsworth and Harlington on the south. As is indicated on the map the areas from which brick-earth has been removed are largely utilised for orchards.

Of the brick-earth associated with the Flood-plain terrace there exist only scattered relics. The most westerly lies between Burnham Abbey and Cippenham; the material does not exceed a foot or two in thickness, and is of no importance.

In the small patch on the east side of Egham on the Surrey side of the Thames, the deposit is about 6 ft. in thickness, and was formerly worked. On the opposite side of the river brick-earth forms the surface soil over part of Staines and Knowle Green. It is a sandy clay, about 4 ft. thick. About 3 miles further east Chattern Hill and Feltham Hill are crowned by brick-earth to a depth of 6 or 8 ft.

Charlton is situated on brick-earth, and between that village and Upper Halliford are several disused brick-pits.

The largest patch of this low-lying brick-earth stretches from the Thames at Laleham through Shepperton Green and Lower Halliford almost to the river again. At Laleham the thickness is almost 6 ft., but at Shepperton Green does not apparently exceed 3 ft.; it was seen at Shepperton Station and was worked in a disused brickfield just to the south. There are other pits by the cross-roads ¾ of a mile to the east, one of which was working in 1911, with the face only 18 ins. in height.

C. N. B.

LANDSLIPS AND SOIL-CREEP.

Besides the deposits described above, some of the ground is occupied by material which it is difficult to show on the map on account of its indefinite character and obscure limits. Some of it is the result of solifluction or soil-creep during the cold period that appears to have followed the deposition of the Taplow Terrace. The superficial parts of beds of all ages have moved down slopes to new positions, and even where there is no slope the subsoil to a depth of 2 or 3 yds. has been contorted and mixed. The effect is greatest where London Clay forms the subsoil, but is often difficult to detect.

On the flanks of Ashley Hill large masses of London Clay have slipped from their original position and overwhelmed the original land surface. In an excavation on the western side of Knowl Hill village Mr. Treacher found a tooth of mammoth buried beneath 12 ft. of clay mixed with stones,[1] which without the evidence of the open section would have been supposed to be London Clay in place.

Round Clewer Green there appeared to be an unbroken expanse of London Clay, but a well-section at Captain Winterbottom's house, near the cemetery, showed 3 ft. of gravel beneath 5 ft. of yellow clay, overlying that formation.[2]

On the steep slope of the river cliff by Cooper's Hill the slipping of the clay, which may be still in progress, is conspicuous; in one part it is possible to distinguish three separate slipped blocks. Near the northernmost point of Runnymede Park an old clay pit showed a land surface with pebbles, broken septaria, flints, &c., covered by 2 to 3 ft. of London Clay, above which was the present soil.

The strata above the London Clay have also been affected by slipping, miniature faulting, and contortion. Slipping has confused the section of St. Ann's Hill (p. 37), and cannot have taken place until the slope was cut about the end of the Taplow Terrace period. At Ongar Hill brick-pit the upper 4 to 6 ft. of the section is much contorted and contains seams and irregular pockets of gravel; overfolding of the gravels by the clay is frequent. The phenomenon of which this section is an example has been discussed in detail by Spurrell,[3] who proposes to apply the term '*Trail*' to the material filling troughs and hollows, a substance dissociated wholly from the beds whence it was derived; '*Underplight*,' for the rocks and beds forming the folds and sides of the hollows, which have been pinched, crumpled, and squeezed, but are still united to the parent rock. He points out that the festooning and contortion in question is not produced at the present day even where extensive slipping is taking place, and concludes 'that the folds or *underplight*, with the puddled sludge or Trail, may have resulted from the heavy pressure of a superincumbent mass of snow on a soil in a condition capable of yielding and frequently repeated' (*ibid.* p. 31).

A fine example of these contortions is to be seen in the north-west corner of the brickyards on St. George's Hill (¼ in. east of the words 'Field Place' on the map); this has been described and figured by Hudleston.[4] The base of the section shows the lilac-grey laminated clays of the lower part of the Bracklesham Beds; this material forms the underplight and has been caught up in pinnacles which are to some extent folded over the trail; the latter has two constituents, gravel and sand derived from the Plateau Gravel capping the hill above, and dark-green glauconitic sand from the upper part of the Bracklesham series which crops out on the flanks. Hudleston's drawing has already been reproduced in a Survey publication.[1] Excavations made in 1913 show that a similar deposit covers a great part of the northern slope of the hill.

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[1] *Proc. Geol. Assoc.*, vol. xxii, 1911, p. 289.

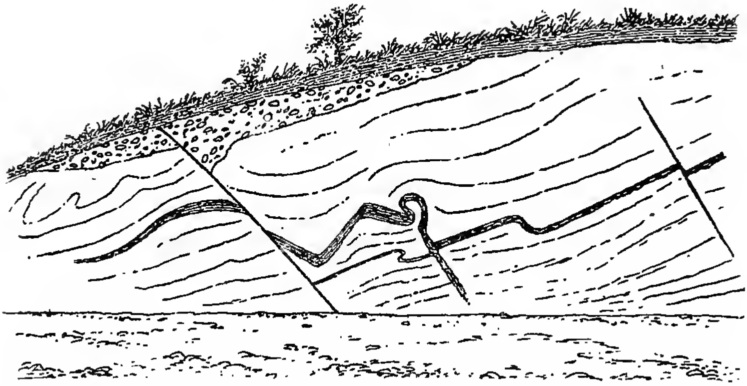
[2] 'The Geology of the London Basin.' *Mem. Geol. Surv.*, vol. iv, 1872, p. 423.

[3] Spurrell, F. C. J. 'History of the Rivers and Denundation of West Kent.' Greenwich, 1886.

[4] *Quart. Journ. Geol. Soc.*, vol. xlii, 1886, p. 170.

An instance of miniature faulting with contortion, probably produced during the cold period, was seen at Brooklands Motor Course; the exact locality is a cutting for an approach-road just south of the railway at the point where the Chertsey branch diverges from the main line. The structure here, as shown in the sketch (fig. 3), is well brought out by the iron-pan which probably represents an old sub-soil surface; the material is Bagshot Sand with a thin cover of soil and pebbly sub-soil.

FIG. 3. MINIATURE FAULTING IN BAGSHOT SAND NEAR WEYBRIDGE.



The river gravels have also been affected by similar movements. Along the northern margin of the map the gravels of the Boyn Hill Terrace have slipped down the intervening slope and now rest on those of the Taplow Terrace (see p. 74). In the paper previously quoted Allen Brown illustrates several clear instances.[2] In situations less favourable to movement contorted 'underplight' may be seen, as for instance, in the gravels of the Walton Railway cutting.[3] The best examples are, however, seen in the Plateau Gravels. Plate V. shows a pit between Warfield Park and Warfield Grove already mentioned (p. 64). The lower part of the section is in well-bedded sandy gravel, the contortions not reaching more than about 6 ft. below the surface; in this upper part the stony and sandy layers are differentiated, and in the former the long axes of the pebbles are parallel to the folding and are frequently vertical. At this locality there is little opportunity for soil-creep on a large scale, as the slope of the ground is very slight. The forces developed by contraction and expansion due to freezing and thawing have therefore expressed themselves by the crumpling of the beds; the depth to which the contortion extends may perhaps be an index of that to which the alternate freezing and thawing reached.

Other examples of the contortion of the upper layers of the Plateau Gravel may be seen at New England Hill, Caesar's Camp, Wagbullock

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[1] 'Geology of the London District.' *Mem. Geol. Surv.*, 1909, p. 84, fig. 17.

[2] *Proc. Geol. Assoc.*, vol. xiv, 1896, pp. 153-173, figs. 2, 3, 4.

[3] Hudleston, W. H. *Op. cit.*, fig. 1, p. 148; fig. 3, p. 151.

Hill, Coppid Beech Lane, and many others. Those seen at Pinewoods were photographed and described by Dr. Irving.[1]

H. D.; C. N. B.

TOP SAND.

In some parts of the district, especially in the southern part, a thin but widespread stratum of fine grey sand is found at the surface, named by Hudleston in his description of the Walton cutting (*op. cit.*, p. 166) ' The Top Sand '; its average thickness is, however, too small for the deposit to require recognition on the geological map. It is evidently derived mainly from Bagshot Beds, but contains a proportion of large, well-rounded grains of quartz, and flint pebbles, nearly always shattered and bleached, are scattered through it. The deposit forms a sterile surface-soil, but fir trees grow well on it, and here and there may be found good oaks and beeches whose roots have penetrated to a congenial sub-soil beneath.

The accumulation of the material was probably slow, and has apparently now ceased; the general character and distribution of the sand is suggestive of wind-drift agency; possibly it was formed on the hills largely from Bagshot materials when the brick-earths were being formed in the valleys (*see* p. 79).

The Top Sand has been shown in figures of sections by Prof. Prestwich,[2] and Mr. Monckton,[3] and described in detail as it occurs round Oatlands by Hudleston.

Round Foxhills Top Sand is abundant, a pit a little way south-west of the house showing 4 ft. of fine bleached sand overlying the loamy beds of the Bracklesham series. The same deposit covers much of the surface round Dunford Farm, New Zealand, and Scotland on the extreme southern margin of the map.

On the north-east flank of St. George's Hill the deposit is frequently as much as 4 ft. thick, and obscures the junction between the Bagshot Sand and Bracklesham Beds (p. 50). On the south side of the hill this sand is to be seen in the old trenches made for working the ironstone, and on the extreme edge of the area, round Silvermere.

C. N. B.

ALLUVIUM AND PEAT.

The Alluvium and Peat shown on the map are of varying age. That occupying the floor of the deserted part of the valley of the Chertsey Bourne may date back almost to Mousterian times; that at Gracious Pond has accumulated since the pond fell into disuse in the sixteenth century. In the valley of the Thames the deposits classed as Alluvium have probably been in process of formation from the Bronze Age up to the present day, and evidently cover a longer period than is represented in the Alluvium of the tidal waters of the estuary.

The fossils or sub-fossils found in the deposits indicate a fauna and flora not greatly different from those of the present day. The more important mammals include Elk (*Alces machlis* Ogilby), Reindeer, Red Deer, Fallow Deer, Roe Deer, Irish Deer (*Cervus giganteus* Blum. sp.), Ox (*Bos longifrons* Owen), Urus (*Bos primigenius* Boj.), Horse, Boar, Beaver, etc., besides recent domestic animals; many of the land and nearly all the fresh-water mollusca now living in the district also occur.

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[1] ' Geological History of the Thames Valley.' *Science Gossip*, 1891, fig. 3.

[2] *Quart. Journ. Geol. Soc.*, vol. xlvi, 1890, fig. 2, p. 161.

[3] *Ibid.*, vol. xlviii, 1892, fig. 2, p. 32.

C. N. B.

LOCAL DETAILS.

In accordance with the plan adopted in describing the older valley deposits the alluvium of the Thames is described first and afterwards that of the tributary streams.

Where the river enters the map from the north it has no bordering alluvium, but to the west of Bray and separated from the river by the gravel on which that village is built there is a channel filled with alluvium, along which a small stream flows, the channel being a continuation of that shown on the Beaconsfield map (Sheet 255), which leaves the Thames near Cookham; it seems to represent a disused backwater.

On the Buckinghamshire side there are several irregular channels filled with alluvium round Dorney and Eton Wick, occupied by small streams draining the Flood-plain gravels. Near Amerden House a section in the river-bank just below Bray Lock showed a seam of sandy loam, which yielded bones of horse, ox, sheep, pig, dog, etc., and many molluscs; part of a bronze sword-scabbard found here is in the British Museum, and has been figured.[1]

At Boveney Lock there is a section showing about 5 ft. of loam containing many land and a few fresh-water mollusca overlying a thin layer of sand crowded with shells, mostly aquatic. A list of mollusca from both beds has been published by Mr. J. E. Cooper, who notes the abundance of *Planorbis stroemi*, West., in the lower band.[2] This lower bed may be contemporaneous with or possibly older than those associated with the peat (lignite) deposits below London, which there underlie the modern alluvium.

At the weir, by the head of Old Windsor Cut, about 6 ft. of sandy loam is exposed, full of shells of *Helix* (*Arianta*) *arbustorum*, Linn. Between Old Windsor and Egham is the wide alluvial flat of Runnymede, but Magna Charta Island is gravelly. Near Bell Weir, about 1 mile west of Staines, is a section of alluvium, which has been studied in detail by Kennard and Woodward,[3] who describe it as follows:—

'Bed 1.—Surface soil: 1 ft.

Bed 2.—Consisting of large black flints mixed with smaller black well-rounded pebbles derived from the lower tertiaries: 2 ft. 6 ins.

Bed 3.—A brick-earth containing several species of mollusca, of which the most noteworthy is *Hygromia rufescens*, since it does not occur in the beds below: 3 ft.

Bed 4.—A marl practically composed of shells: 1 ft.

Bed 5.—Calcareous loam. Several species of mollusca were also obtained from this bed, which also contained calcareous concretions, fragments of flint, and some plant remains, including leaves and stem of *Crataegus oxyacantha*, Linn., and *Salix viminalis*, Linn., as well as small portions of aquatic plants and rushes. This bed also yielded two teeth of the pike (*Esox lucius*, Linn.), and a tooth of either dog or wolf: 2¼ ft.

Caddis worm cases, probably of *Limnophilus flavicornis* were also met with in Bed 4.'

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[1] 'The Antiquities of the Bronze Age.' *Brit. Mus. Guide*, 1904, p. 37, fig. 14.

[2] 'Holocene Deposit at Boveney.' *Proc. Malac. Soc.*, vol. x, 1913, pp. 318-319.

[3] 'Sections of the Holocene Alluvium at Staines and Wargrave.' *Proc. Geol. Assoc.*, vol. xix, 1906, pp. 252-256.

The following is a list of the mollusca identified by Messrs. Kennard and Woodward from this section :—

Vitrea crystallina (*Müll.*).
,, nitidula (*Drap.*).
,, radiatula (*Alder*).
Zonitoides nitidus (*Müll.*).
Arion ater (*Linn.*).
Punctum pygmaeum (*Drap.*).
Pyramidula rotundata (*Müll.*).
Helicella itala (*Linn.*).
Hygromia hispida (*Linn.*).
,, rufescens (*Penn.*).
,, sericea (*Drap.*).[1]
Vallonia pulchella (*Müll.*).
,, excentrica *Sterki.*
Helicigona[2] arbustorum (*Linn.*).
Helix nemoralis *Linn.*
Cochlicopa lubrica (*Müll.*).
Caecilioides acicula (*Müll.*).
Jaminia muscorum (*Linn.*).
Vertigo minutissima (*Hart.*).
,, pygmaea *Drap.*
Clausilia laminata (*Mont.*).
Succinea putris (*Linn.*).
,, elegans *Risso.*
Carychium minimum *Müll.*
Ancylus fluviatilis *Müll.*
Acroloxus lacustris (*Linn.*).
Limnaea auricularia (*Linn.*).
,, pereger (*Müll.*).
,, palustris (*Müll.*).
,, truncatula (*Müll.*).
Limnaea stagnalis (*Linn.*).
Amphipeplea glutinosa (*Müll.*).
Planorbis corneus (*Linn.*).
,, albus (*Müll.*).
,, stroemi *West.*
,, crista (*Linn.*).
,, carinatus (*Müll.*).
,, umbilicatus (*Müll.*).
,, vortex (*Linn.*).
,, spirorbis (*Linn.*).
,, contortus (*Linn.*).
,, fontanus (*Lightf.*).
Physa fontinalis (*Linn.*).
Bithynia tentaculata (*Linn.*).
,, leachii (*Shepp.*).
Valvata piscinalis (*Müll.*).
,, cristata *Müll.*
Neritina fluviatilis (*Linn.*).
Anodonta cygnea (*Linn.*).
Sphaerium corneum *Linn.*
Pisidium amnicum (*Müll.*).
,, supinum *A. Schm.*
,, henslowianum (*Shepp.*)
,, subtruncatum *Malm.*
,, pulchellum *Jenyns.*
,, pusillum (*Gmel.*).
,, nitidum *Jenyns.*
,, obtusale *Pfr.*
,, gassiesianum *Dupuy.*

In a later list of 50 species of mollusca from an excavation at Staines Gas Works, published by Mr. Cooper[3] it is mentioned that 'several species found by Messrs. Kennard and Woodward did not occur in this section; the only two species additional to their list are *Helix hortensis* and *Vallonia costata.*'

Below Staines the Thames is bordered by a wider expanse of alluvium stretching as far as Chertsey, where it is interrupted by the gravel island on which that town stands; this alluvial tract is traversed by the Abbey River, the Burway Ditch, and other small streams, and is frequently flooded. The alluvium is underlain by gravel which is dredged to a small extent at a water-filled pit between Savory's Weir and Mixnams. Between Chertsey Mead and Walton is another comparatively wide spread of alluvium, which is narrowed below Walton Bridge.

In the valley of the Blackwater, in the extreme south-west corner of the district, the alluvium forms a tract of meadow land on either side of the river some half-a-mile in total width, and gradually merges into the peaty swamp of Broadmoor Bottom. At the 'Jolly Farmers,' Sandhurst, a temporary section showed 8 ft. of alluvium consisting of sticky green sand and peat in layers overlying gravel. South of Easthampstead Park there is a marshy tract of alluvium belonging to a small feeder of the Blackwater.

The stream draining the country round White Waltham which, since the digging of The Cut, receives the waters of the Binfield Brook, is bordered by alluvial meadows where it flows over Tertiary beds; where it cuts through the Taplow Terrace by Bray Wick, the valley narrows, and below this point the stream follows the line of the old Thames backwater mentioned above.

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[1] *H. sericea,* Drap., added to original list. See *Proc. Malac. Soc.*, vol. viii, 1908, p. 92.

[2] Elsewhere referred to as *Arianta.*

[3] Cooper, J. E. 'Holocene Mollusca from Staines.' *Proc. Malac. Soc.*, vol. vii, 1907, p. 311.

In the valley of the Colne there is a wide spread of alluvium across which the river meanders in a network of little streams. The alluvium is everywhere underlain by gravel and shows an average thickness of 4 ft., which increases near the mouth. In this alluvium were found a skull, antlers, and other remains of the elk (*Alces machlis*), together with bones of deer (*Cervus elaphus*), fallow deer (*Cervus dama*), pig (*Sus scrofa*), and horse (*Equus caballus*). A full description of the specimens and of the conditions under which they were found was published by Mr. E. T. Newton.[1] The bones are preserved in the Museum of Practical Geology.

Between Bracknell and Virginia Water, a stream, which rises near South Ascot, flows through a peat swamp; the peat is now about 3 ft. thick but was formerly much thicker and was dug for fuel many years ago. The chalybeate springs at Sunninghill Wells bubbled up through this peat and the waters trickling down to join the stream deposited a red slime on the weeds. A bog which formerly occupied the low ground was drained about 1750 to form Virginia Water; the lake was afterwards enlarged and more of the alluvial tract submerged by the erection of the dam, the overflow at which now produces the famous cascade.

The alluvium of this stream, the Chertsey Bourne, near Trumps Green, is in part peaty, and at one point in the bank was seen to be at least 6 ft. in thickness. Where the valley debouches on the Thames flood-plain there is a wide alluvial fan reaching to Thorpe, which may be accounted for by the increased activity of the stream since its diversion (see below, p. 89). The alluvium follows the course of the stream through Chertsey to the confluence with the Wey. In the abandoned course we find a deposit of peat and red clay by the Almners and of alluvium between Sandgates and St. Ann's Hill and also in the first stretch to be abandoned, that running south-eastwards through Addlestone.

In the valley of the Hale Bourne there are considerable areas shown on the map as alluvium. It has been pointed out as characteristic of the Bagshot Sands to form wide marshy or peaty flats while the clays occupy the hillsides. To this tendency are due the extensive alluvial tracts between Bagshot and Windlesham and around Chobham. Here many islands of gravel rise above treacherous swamps of peat. Near Burrowhill there is a thick growth of moss, while at Penny Pot a section showed 4 ft. of clay overlying peat with large stems of plants. Below Woodham the stream meanders from side to side of a narrow alluvial tract which at Ham becomes merged in that of the Wey.

The alluvium of the latter river is of little importance geologically, but has yielded many interesting relics of the Bronze Age. Several of these have been described and figured by Dr. Eric Gardner;[2] who suggests that there was an ancient ford near the present Weybridge.

H. D.; C. N. B.

RIVER DEVELOPMENT.

The three terraces on which the fluviatile deposits of the Thames have been distributed have been described above; it remains to discuss certain inferences that may be drawn from them. On the eastern side of the map they form a succession from north to south. The Boyn Hill Terrace of the Thames is here present only on the extreme northern edge of the area; south of this comes a wide expanse of the Taplow Terrace partially covered by brickearths; to the south again is a great stretch of flood-plain gravels and brick-earths, bounded by the present course of the Thames, which impinges on or is but a little distance from a prominent and well-formed river cliff. It is therefore evident that from Boyn Hill times onwards the Thames in this part of its course has had a persistent tendency to sweep further south, corroding the soft Tertiary strata and leaving behind the gravels laid down by its own action. This tendency is to be explained by several facts. A large body of water enters the Thames from the north near the point at which the southerly bend begins. At the period when the country to the north was occupied by the margin of an ice-sheet, the flow of water from that direction would bring with it a heavy load of gravel and give a strong southerly impulse to the Thames at the confluence; this impulse is continued at the present time by the entrance of the Colne.

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[1] 'The Elk in the Thames Valley.' *Quart. Journ. Geol. Soc.*, vol. lix, 1903, pp. 80-90, plate v.

[2] 'The British Stronghold of St. George's Hill, Weybridge.' *Surrey Arch. Coll.*, vol. xxiv, 1911, pp. 40-55, Plate i-vi.

The Effects of Structure.—Again it has been stated (pp. 17, 18) that the Tertiary strata are thrown into a gentle syncline, whose axis runs north-east to meet the Thames near Chertsey. From Windsor to Chertsey the Thames was therefore removing the Bagshot Sands, and working along a gently dipping surface of London Clay; the limit of the southerly trend of the river occurs where the axis of the syncline is reached, and the dip no longer helps the river to cut in that direction. The turn to the north from Weybridge past Walton finds an additional cause in the entrance from the south of the river Wey.

Gradients.—It has been pointed out by Mr. Pocock, who mapped a large part of the area occupied by the Thames deposits, that from the neighbourhood of Staines eastwards the three terraces maintain practically constant levels. From this constancy of level he concludes that from Staines the ancient Thames 'flowed at the sea-level, like the tidal part of the modern Thames, or else that it formed a broad lake-like expansion which was held in by a barrier separating it from the sea.'[1] Many miles east of London, however, the deposits on the corresponding terraces yield shells of fresh-water origin, such as *Neritina*, and it is therefore impossible that tidal conditions should have reached as far inland as the district now under discussion. The low gradient observable in the surface of the gravel terraces is rather due to the grading of its bed by the river as it dropped its load of gravel. The 'plains tract' thus formed is practically coincident with that part of its course in which the river is flowing over Tertiary strata, and, roughly speaking, begins where it enters the present map, its course through the country to the north (Sheet 255) belonging to the 'valley tract.'

Near Windsor, however, there is a slight change in the grade of the terraces, due to the dome-like outcrop of chalk, denudation of which would take place at a slower rate than of the soft Tertiary strata. A similar instance of the effect of a boss of chalk on the gradient at successive periods has been described by Messrs. Hinton and Kennard at Grays.[1] It will be noticed that where the Thames enters the map from the north the three terraces in succession are present on the western side; that is to say, the river has in successive periods encroached on its left bank, a feature which is continued several miles to the north and has produced the cliff at Clieveden Woods. At Bray the southerly trend ceases; the river has failed to force a passage south of the Windsor dome, the influence of which is now felt. As soon as it has passed this obstacle it commences the great southerly loop described above.

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[1] 'Summary of Progress for 1902.' *Mem. Geol. Surv.*, 1903, p. 203.

Diversions.—This southward encroachment by the Thames has diverted some of the tributary streams. It is clear that when the Thames flowed some ten miles to the north of Weybridge, during the period of the Boyn Hill Terrace, the independent course of the Wey must have been prolonged by at least that distance to the north. Probably it flowed approximately in a northerly direction and joined the Thames in the neighbourhood of Ealing, but its valley has been obliterated by the Thames. The Mole also has been greatly affected. Its ancient course up to the end of the Taplow period can be traced with some certainty and will be described in the Memoir on Sheet 270.

Chertsey Bourne.—Near Chertsey there is an interesting case of stream diversion the history of which can be traced in detail. It has already been mentioned that St. Ann's Hill is an 'island' of Tertiary strata surrounded by river-deposits. It is separated from the main mass of the Tertiary Beds by a band of alluvium and gravel of the Taplow Terrace, stretching in a south-easterly direction from Virginia Water; this continuous belt is bordered on either side by isolated patches of Boyn Hill gravel. It is clear that those gravels do not associate themselves in their distribution with the Thames, from the valley of which they are separated by the high ground of Callow and St. Ann's Hills (*see* map, fig. 4); on the contrary, they mark the track of a river-course stretching from Virginia Water Lake, just beyond the western corner of the map to Cockcrow Hill; but when we look for the stream which laid them down we find that the eastern half of the valley is dry. For the Bourne, which flows along the western part, suddenly abandons the line of gravels, and turns to the north between Callow Hill and St. Ann's, thence finding a course across the flood-plain gravels of the Thames.

Along the valley running to the south of the hills there must once have flowed a considerable stream: for the Boyn Hill gravels, though now represented only by isolated patches, appear once to have extended more than a mile in width; on the other hand, the Taplow gravels as a narrower belt are fairly continuous, and associated with them there remains a considerable deposit of peaty alluvium which, where it lies to the south of Cockcrow and Sandgates, must be of approximately Taplow age, while the rest is not much newer.

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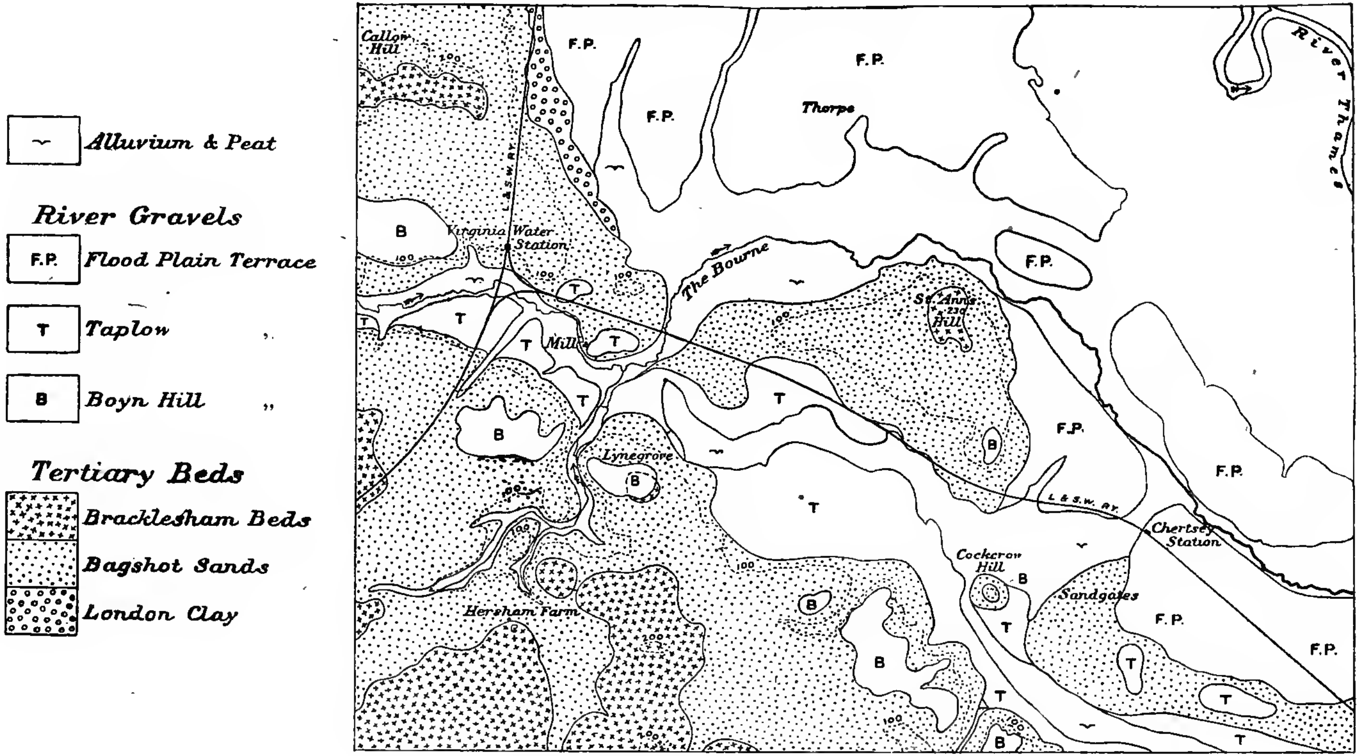
[1] *Essex Naturalist*, vol. xv, 1907, p. 69.

FIG. 4. GEOLOGICAL MAP OF THE BOURNE VALLEY.



Scale; three inches = two miles.

Following upon the deposition of the Taplow gravels important changes took place. The Thames now flowing at a lower level undercut its right bank and encroached upon the Tertiary area until a way was opened for the passage of the flood waters of the Bourne between St. Anne's and Cockcrow Hills: the adoption of this new course now left Sandgates and Cockcrow Hills as outstanding islands, while St. Anne's still remained a part of the main mass.

As the planation by the Thames continued a new river-cliff was formed a little higher up stream. St. Ann's Hill is formed of Bagshot Beds of an unusually loamy facies, capped by Bracklesham Clays with a thick pebble-bed and some plateau-gravel, whereas on either side of it the sands are loose; it has consequently resisted corrosion and now projects into the Thames flood-plain. On the north side of this projection the Bourne waters were again diverted, and the whole of the lower valley including the previous diversion was abandoned.

The effects of this change are noticeable both in the valley of the Bourne itself and in the upper part of the Lynegrove brook. Between the two points where it is crossed by railways the Bourne has obviously acquired an increased gradient, as a consequence of which the channel is deeper and the banks more abrupt than in the upper reaches where the change has not yet made itself felt. This deepening of the bed has laid open the Bagshot sand below the Taplow terrace, a feature not found anywhere else in the neighbourhood. Similarly the Lynegrove brook near Hersham Farm has cut a little notch in its old plain leaving minute terraces on each side. Where the Bourne reaches this Thames flood-plain it has spread out the material removed by its new activity as an expanse of alluvium which at first sight appears much too big for so small a stream.

Hale Bourne.—Another point of interest is afforded by the Hale Bourne, the stream which flows from Bagshot through Chobham and Addlestone to Weybridge. The valley of this Bourne debouches on that of the Wey, near Woodside, but the stream then turns north and flows parallel to the Wey for some two miles before joining it at Weybridge. The phenomenon of which this is an example has been described under the name 'postponed junction.'[1] The confluence must once have occurred near Woodside, where the valleys unite, but the deposition of material by the river at the point of junction drives that point continually further down stream, leaving a barrier of gravel and sand between the two. It is noticeable that in this district the Wey has at successive periods shifted its course eastwards and now flows at the foot of a cliff of Tertiary strata on its right bank.

C. N. B.

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[1] White, H. J. O. 'On a Peculiarity in the course of certain streams in the London and Hampshire Basins.' *Proc. Geol. Assoc.*, vol. xvii, 1902, pp. 399-413.

CHAPTER VII.

ECONOMIC GEOLOGY.

BRICK-MAKING.

Brick-making is the most important industry of the district, and is centred chiefly around Bracknell. The clay is obtained from the Bracklesham Beds, the London Clay, the Reading Beds, and the Thames Valley Deposits. The Bracklesham Beds yield the clay employed in the manufacture of the 'rubber bricks' so much favoured by architects, while the London Clay and brick-earths of the Thames deposits are worked extensively for stocks and red bricks.

The annual output varies according to demand, but averages fifteen millions of bricks and about a million tiles.

The kilns in which the bricks are burnt vary in pattern; the largest are the oval continuous-firing kilns; but Scotch and other kilns are also used. The methods of mixing the raw material also vary both according to class of brick required and to the method of manufacture. Most of the drying is done in steam drying sheds; a few bricks, however, are air-dried.

The Reading Beds are worked on a large scale for bricks and tiles at the 'Star' Works, Knowl Hill. The material used is for the most part the mottled clay of the middle part of the series. For the following analysis of the clay after 3·78 per cent. of moisture had been driven off we are indebted to the proprietors of the works, Messrs. Warner:—

	Per cent.
Silica	50·00
Iron (Ferric oxide)	11·30
Alumina	21·10
Lime	4·10
Magnesia	0·70
Potash, Soda, Phosphoric and Sulphuric acid	12.80
	100·00

Analyses of other beds at the same pit gave 59 and 78 per cent. of silica.

The output consists of red bricks and tiles of all sorts; and the preparation of a blue brick by stronger firing has been recently introduced.

Sand for mixing with the clay is obtained from the upper part of the same pit and a good plaster sand was formerly worked near the base.

The London Clay is the most important brick clay of the district. The composition of the raw material from this source worked at the Down Mill Brick Co.'s pit at Bracknell is shown in the following analyses[1]:—

	1. Red Clay. Per cent.	2. Blue Clay. Per cent.
SiO_2	73·4	71·00
Al_2O_3	5·95	10·8
Fe_2O_3	6·35	3·7
CaO	13·80	9·8
Combined water, Organic matter (Alkalies), and Phosphoric acid	0·50	5·7
	100·00	100·00

1. In this clay there was 2·3 per cent. of moisture.
2. This analysis is of the clay dried at 100° until the weight was constant: the moisture which was then driven off amounted to 3·88 per cent.

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[1] Analyses by C. D. Cooper, The Laboratory, Reading.

Small brick-yards at Coppid Beech Lane, near Wokingham and at Ascot, both in London Clay, produce about a million bricks and tiles a year for local use. There are disused brick-works round Binfield, Winkfield, Egham, and other places.

The Bracklesham Beds yield loamy clay suitable for certain classes of brick. They are dug at Crowthorne Brick Works for local use and were formerly worked for bricks at several other places in the neighbourhood.

There are some disused brick-pits near Chobham Common, and rubber bricks of good quality were made near Valley End and at Titlark's Farm. The pits were closed because they disfigured the Common. Another small yard at Windlesham produces some 200,000 bricks per annum, from clay dug from the Upper Loams of the Bracklesham Beds.

The most important brick-works in the Bracklesham Clay are at Swinley, where the noted 'T.L.B.' rubber bricks are manufactured. The clays are glauconitic and loamy and are worked in wide shallow pits. Besides the active workings there are several other pits in the vicinity at present disused.

At Ongar Hill and Hatch Pits, near Woburn Park, a few bricks are still made from the Bracklesham Clays. The Fir Grove Pit on St. George's Hill has fallen into disuse during the last few years, and the sections have been destroyed in the development of the estate for building purposes.

The Brick-earth of the Thames valley has been extensively worked round Slough, Langley, West Drayton, and Dawley. From large areas it has been removed completely, exposing the gravel beneath. This, in turn, has frequently been worked almost down to the water-level (see p. 80). The areas thus treated have been found to make excellent sites for orchards and market gardens. At Slough the earth is still worked for brick-making; the material does not require the addition of sand or chalk, and does not contain stones. The working face varies in height from 3 to 8½ ft.; the irregularity is due to the surface configuration, the junction with the underlying gravels being even. Both red and stock bricks are made from this material.

IRONSTONE.

Ironstone for smelting was formerly dug round St. George's Hill. The ore is an impure carbonate of iron occurring at the junction of the Bracklesham and Bagshot series (*see* p. 51); a sample analysed in the Survey laboratory yielded 23 per cent. of iron. The method of working was by trenches from 5 to 15 ft. deep following the outcrop of the bed; according to the nature of the ground the workings contracted to a single trench or spread out in a sheaf; they are well seen on the west and south of the hill.

For information concerning the mills at which the ore was worked we are indebted to Dr. Eric Gardner, of Weybridge; the earliest mention that he has discovered is a lease, dated 1779, from which we quote the following:—'And further that neither the said Fletcher Norton and James Champain nor their nor either of their executors administrators or assigns shall or will during the term hereby granted use or follow any business in the said mills . . . that will require a great Hammer to be worked by Water.' The site of the mills, as shown by the Ordnance map of 1816, was that now occupied by Lock Mills, and the proviso as to use of water-power was no doubt intended to safeguard the River Wey navigation. An Act of 1803 (44 George III., cap. xxv.) mentions 'All those Two Iron Mills erected on the banks of the said River [Wey] . . used . . . in the Iron and Steel Manufacture.' Dr. Gardner has in his possession two tokens for one shilling and one penny respectively, issued by J. Bunn and Co., Weybridge Iron Mills: the penny has on the obverse a sketch of the mills, showing a two-gabled building with four tall chimney stacks and a large water-wheel, lettered beneath, 'Weybridge Mills': on the reverse an inscription in the field, 'One Penny Payable at Weybridge. I. Bunn & Co., 1812,' and round the margin, 'Hoop & Iron Warehouse. Dowgate Wharf.'

There is evidence, therefore, that the works were in existence for more than 33 years; no other ironworkings are known in this part of the country, nor has any other Tertiary iron ore been worked in the Thames Basin. In the Hampshire Basin, ore of approximately the same age was worked at Hengistbury Head.[1]

SAND AND SANDSTONE.

The Bagshot Sands are worked for moulding and casting sand by the London and South-Western Railway Company in a large pit beside the cutting south of Coppid Beech Lane.

An extremely fine-grained and powdery variety of the sand which occurs locally at Burrow Hill, Chobham, and on Chobham Common is dug for polishing and tooth powders. Under the microscope it reveals no peculiarity of composition, as the material consists mostly of quartz, with mica and felspar. The fine sand occurs in a bed about 3 feet thick resting on another sand of normal character. It is being worked by the Lincoln Mineral Co., Ltd., Point Pleasant Works, Wandsworth.

Large pits have been excavated in Bagshot sand at St. Ann's Hill, but are only worked to a small extent now.

Sarsen Stone or greywether sandstone forms 'an admirable building stone dressing easily to an even face, almost indestructible by the weather, and of a pleasing grey tint. Examples may be seen at Windsor Castle, great part of which is built of this stone.'[2] It was also used for paving stones and road setts, but is no longer worked (*see* p. 58). When the industry was in operation, the position of the greywethers was found by sounding the sand with iron rods. On Chobham Common and at the Camp large sarsens were exceptionally plentiful, and were used for the grotto and waterfall at Virginia Water.

GRAVEL.

The principal material used for roads in this district is the various gravels. There are several wide shallow pits at the margins of Easthampstead Plain where the gravel is dug and screened. The sand is rejected and used to fill up the old working, the stones are sorted into heaps, the top gravel bleached by weathering being carefully set apart from the gravel of good colour which is suitable for paths and roads, the bleached gravel being rejected.

The principal pits are at Penny Hill, Black Hill, Long Down and Crowthorne; Curley Hill or High Curley, Bagshot; and the Hut Pits and Wagbullock Hill. There are besides many small pits for local supply.

Near Bagshot small rounded pebbles are dug for mixing with cement.

The pebble beds are dug for road stone at Bracknell and Stannershill.

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[1] 'Geology of the Country around Bournemouth.' *Mem. Geol. Surv.*, 1898, p. 8.

[2] Whitaker, W. *Mem. Geol. Surv.*, vol. iv, part 1, p. 390.

The gravels of the Thames have been extensively worked; though not now used on the main roads, a large amount of gravel is still dug for by-roads and paths. The most important pits are those round Shopperhanger's Farm, at Cippenham, Salt Hill, and Dawley.

PEAT.

Peat was formerly dug at South Ascot for fuel, but the practice has long been given up.

Near Burrowhill, at Langshot Bog, the deep moss is dug and spread out to dry on the heath. It is used in packing Rhododendron plants for export, and is also utilised in preparing the soil when they reach their destination.

WATER SUPPLY.

Most of the water supply of the more populous parts of the district is obtained from the several public water companies as shown in the table (p. 95). The old wells from which private supplies were formerly drawn are for the most part disused and sealed up. The composition of several of the formations is, however, favourable for the storage of water; but the risk of pollution from the surface is usually great.

The Barton Sands are permeable throughout, owing to the absence of clay-partings, so that water penetrates them to their base and issues as springs to form swamps and marshes on the Bracklesham Clays (*see* p. 42).

The Bracklesham Beds consist of a series of impermeable and partly permeable layers alternating with one another. The sands are often glauconitic and seldom pure, and the presence of iron pyrites frequently renders the waters malodorous and unpotable.

The Bagshot Sands are for the most part permeable and yield a limited supply sufficient for private requirements. The water is frequently held up by the thin partings of clay, and is reached in many shallow wells; but it is sometimes unfit for drinking.

The chalybeate well at Sunninghill was formerly renowned for its medicinal properties and ranked as an equal to Bath and Tunbridge Wells. In 1666[1] it was visited by John Locke, and is mentioned in Horace Walpole's letters. During the time of the Peninsular War the wells were much resorted to by military invalids, but soon after began to decline in popularity.

The great mass of the London Clay is impermeable, but the basement bed passes down into sands which form the upper member of the Reading Beds: a well recently sunk at Honeys obtained water from this horizon.

The lower part of the Reading series is sandy and occasionally yields sufficient water for small houses, as for instance round West End.

The Chalk is of considerable importance as a water-bearing stratum in parts of the district. In the area where it outcrops at the surface sunk-wells supply the houses, and in all the larger towns there are bored-wells reaching the Chalk, as for instance at Windsor, Slough, West Drayton, Staines and Chertsey. Where the cover of Tertiary strata is great the Chalk is usually dry; this was the case at New Lodge, Egham, Virginia Water, and Ottershaw.

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[1] Hughes, 'History of Windsor Forest.' 1890, pp. 260-268.

Borings have reached the Lower Greensand at New Lodge near Winkfield, Slough, and Ottershaw Park; the supply of water was in each case large, but at the last-named it is somewhat ferruginous.

Details of well-sections have already been published for a large part of the area covered by the map under description in 'The Water Supply of Berkshire' (*Mem. Geol. Surv.*, 1902) and 'The Water Supply of Surrey' (*Mem. Geol. Surv.*, 1912). The more important of these sections are reprinted below in abstract, together with others not hitherto published.

The principal towns and the large villages are supplied by the several public water companies with water obtained either from the Thames or from deep wells. The following list gives the name of the Water Company, source of the water, and places supplied.[1]

Name of Company.	Source of Water.	Places supplied.
Wokingham District Water Company.	Deep Well in chalk ...	Bracknell, Bullbrook, Warfield, Binfield, etc.
Windsor Corporation ...	Wells in gravel and chalk.	Windsor, Eton, Clewer.
South-west Suburban Water Company.	Thames and Wells ...	Egham, Staines, Ascot, Sunninghill, Sunningdale, Cranford, Bedfont, Thorpe, Old Windsor, Bagshot, Windlesham.
West Surrey Water Company.	Thames	Weybridge, Chertsey, Addlestone, Oatlands, Byfleet.
Frimley and Farnborough District Water Company.	From wells and springs outside the limits of the map.	Wellington College, Sandhurst and Crowthorne.

The Metropolitan Water Board obtains a large amount of water from the Thames at Bell Weir: the water is stored in the reservoirs at Staines, which have a capacity of 3,338 million gallons, and supplied to the works at Hanworth Road, Kempton Park, and Hampton. During the year April, 1912—March, 1913, the daily average quantity of water supplied was about 60 million gallons.[2]

Accounts will be found in the following pages of a number of well-sections not previously published. There are, however, 87 well-sections within the area of which accounts have appeared in previous memoirs. References to these accounts are given in every case, but a few of them, including all of which the sites are engraved on the map, are reproduced in full.

H. D.; C. N. B.

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[1] Compiled from information given in the 'Water Works Directory and Statistics,' 1911-12, London.

[2] 'Tenth Annual Report,' Metropolitan Water Board, London, 1913.

APPENDIX I.—SECTIONS OF WELLS AND BORINGS.

ABBREVIATIONS.

L.M.—'Geology of London,' vol. II. *Mem. Geol. Surv.*, 1889.

W.S.B.—'Water Supply of Berkshire.' *Mem. Geol. Surv.*, 1902.

P.G.S.—'Summary of Progress for 1906. Appendix III. Some Well-sections in Middlesex.' *Mem. Geol. Surv.*, 1907.

W.S.S.—'Water Supply of Surrey.' *Mem. Geol. Surv.*, 1912.

The localities are arranged in alphabetical order for each county.

BERKSHIRE.

Ascot.

1. Race Course.

About 250 ft. above Ordnance Datum.
Made and communicated by Messrs. S. F. BAKER & SON.
Shaft 250 ft., the rest bored.
Supply so small that the well was abandoned.
[Site engraved on map.]

		Thickness. Ft.	Depth. Ft.
Surface Soil.	Loam...	3	3
[Lower Bagshot Beds.]	Hard grey and yellow sand	42	
	,, ,, sandy clay and pebbles ...	5	
	Fine grey sand with a foot of brown clay	18	68
[Claygate Beds ?]	Brown sandy loam, brown shale and sandy clay	38½	
	Grey sand and sand and clay	10½	
[London Clay]	Blue clay	295	
	Brown sandy clay and fine sand. Basement bed.	5½	417½
[Reading Beds.]	Brown mottled clay and sand	48	
	Sand and pebbles	5¼	
	Light brown clay, sandstone and black clay	15½	
	Missing bed	4	490¼
	Chalk...	220	710¼

A detailed account of this well is published in W.S.B., pp. 19 and 20.

2. The Village of Ascot, etc. 1878.

In the 'Water Supply of Berkshire' (pp. 20-21) part of the report by Dr. Ballard to Local Government Board, dated 10th July, 1878, is reproduced. After quoting Mr. C. E. Hawkins' description of the Lower Bagshot Sands, from which the whole of the water for the district was then obtained, he gives an account of 22 wells in and around Ascot. Most of these wells are now superseded by the public supply, so that it will suffice to reproduce particulars of ten only. The information is here arranged in three columns instead of four. The first column gives the approximate height of the top of the well above Ordnance Datum in feet (=O.D.); the second the total depth of the well from the surface (=Depth); the third the depth of water in the well (=Water).

	O.D.	Depth.	Water.	
	Ft.	Ft.	Ft.	in.
1. Well at Ascot Hotel	307	74	4	0
3. House Well at "Heatherfield"	307	80	3	6
5. Well at Gothic House	280	50	5	2
8. Well at Ascot Wood House (New Well) ...	273	52	3	2
14. Well at Ashby's, New Mill Lane	265	41	14	0
16. Well at Cowies', New Mill Lane	260	36	8	10
18. Well at Sunninghill House School, Ascot ...	260	42⅔	4	1
19. ,, ,, ,, (Garden Well)	225	25	7	6
20. Well at Mr. Critchers, Keep's Corner	230	12½	9	0
22. Well at Brick Kiln Farm	240	22½	6	0

Bray.

1. Oakley Court [close to the Thames].
80 ft. above Ordnance Datum.
Made and communicated by Messrs. Merryweather & Co.
Supply tested to 2,500 gallons an hour, with no signs of exhaustion.
Hardness, 14°.

		Thickness. Ft.	Depth. Ft.
[River Deposits.] 19 ft.	Old Well	17	17
	Sand and Gravel	2	19
[London Clay.] 25 ft.	Blue clay	25	44
[Reading Beds.] 76 ft.	Mottled clay	20½	
	Red sand	3	
	Sandstone	1½	
	Red sand	12	
	Dark sand	6	
	Light sand	3	
	Mottled clay	28	
	Sand and pebbles	2	120
[Upper Chalk.]	Chalk	100	220

2. Stafferton Lodge, close to the Thames. See **Maidenhead.**

Bracknell.

Hawthorne Hill [this well is at Hawthorne Dale House,
in the parish of Warfield and about 2½ miles north of Bracknell].
About 200 ft. above Ordnance Datum.
Shaft, 6 ft. in diameter for 40 ft.; rest, a 6-in. bore. Water 80 ft. down.
Made and communicated by Messrs. Tilley. 1880.

Water level same in 1914; yield 800 to 900 gallons an hour. Information from Mr. G. H. Burgess.

London Clay 140 ft.; Reading Beds 78 ft.; Upper Chalk 227. Total 445. For further details see W.S.B., p. 27.

Clewer Green.

About 1 mile south-west of Windsor.

1. Captain Winterbottom's ... ... W.S.B., p. 38.
River Deposits 8 ft.; Lower Tertiary 262 ft.; in Chalk 66 ft.
Sunk 42 ft., rest bored. Water 35 ft. down.

2. Wycombe Cottage ... ... W.S.B., p. 39.
Lower Tertiary 169 ft.; in Chalk 97 ft.
Sunk 20 ft., the rest bored. No record of water obtained.

Maidenhead.

Stafferton Lodge [close to the Thames] ... ... W.S.B., p. 56.
Old well in River Deposits 23 ft.; 6-in. bore carried 13 ft. into Chalk.
No other details.

Old Windsor.

1. Lock. Trial-boring, 1871 ... ... W.S.B., p. 63.
Situated ¼ mile north-west of Lock.
River Deposits 20 ft.; Lower Tertiaries 118 ft.; in Chalk 15 ft.
Water 35 ft. down.

2. Pelham Place ... ... W.S.B., p. 63.
London Clay 142 ft.; Reading Beds 80 ft.; in Chalk 9 ft. No other details.

3. The Union, 1852 ... ... W.S.B., p. 64.
4. The Union, 1888 ... ... W.S.B., p. 64.

The first was a shaft to 60 ft., with a boring below to 287 ft. or more.

In 1888 a new boring was made from the bottom of the well by Messrs. C. Isler and Co. London Clay 197 ft.; Reading Beds 70 ft.; in Chalk with flints 163 ft.; total 430 ft.

When the first well was made the water level was 35 ft. down; in 1888, with pumps, 170 ft. down, the supply was exhausted in 10 minutes; with suction at 430 ft. the yield was 720 gallons an hour. The Union is on the rising ground to the south-west of the town; height above O.D. is about 90 ft. The present yield is about 3,000 gallons a day; water 360 ft. down.

Sandhurst.

1. Wellington College.

About 300 ft. above Ordnance Datum.

[Site engraved on map.]

Well 6 ft. diameter at top, diminishing to 3½ ft. at 200 down; below, a 12-in. bore for 550 ft.; total 750 ft. Water usually stood at 80 ft. below ground-level, and we used roughly 30,000 gallons in the 24 hours. It has not been in use for the last 8 years. [*Information from the Bursar*, 1914.]

An account in the *2nd Annual Report Wellington College Nat. Sci. Soc.*, pp. 24-26 (1871) gives the section below.

		Thickness. Ft.	Depth. Ft.
Surface Soil			
[? Upper Bagshot, and (?) Bracklesham Beds.]	Sand and sandstone [? firm sand], with fragments of iron-pyrites. At a depth of 37 feet a bed of black pebbles. A bed of lignite ... about	63	63
[Bracklesham Beds.]	Green sand and clay; at first sandy and only slightly green (8 ft.); then hardened dark green clay (6 ft.). *Venericardia planicosta*, 5-7 and 15 ft. down	17	80
	Greyish laminated clay	2	82
[Lower Bagshot.]	Brown and grey sands	110	192
[London Clay.]	Clay with stones [? septaria] every 5 ft.; flint pebble, 229 ft. down ...	288	480
	Liver-coloured clays at a depth of 500 ft.		
[Reading Beds.]	Mottled clays at a depth of 538 ft. ...		
	Greenish clay at a depth of 570 ft., getting more sandy, showing traces of chalk at a depth of 586 ft., which become more plentiful until chalk is reached	—	604
Chalk [according to Sir F. Bramwell]		130	734

There are two other accounts of this well which differ slightly from the above: for particulars, see W.S.B., pp. 70 and 71.

2. Ambarrow ... ... W.S.B., p. 72.

Shottesbrook.

1. Chambers's (or Shottesbrook) Farm.
135 ft. above Ordnance Datum.
Well in chalk. Depth 48 ft.
Water varies from 14 ft. to dry during 15 years previous to 1910.
Information obtained on the spot.

2. Shottesbrook Park ... ... W.S.B., p. 73.
Bore 10 in. diameter to 80 ft. in Chalk. Tilley & Sons, 1897.
Good supply.

Sunningdale.

South of Virginia Water.

1. The Golf Links; half-a-mile south of Titlark Farm.
About 200 ft. above Ordnance Datum.
Water plentiful.

		Ft.
Bracklesham Beds.	Clay	10
Bagshot Beds.	White sand	38

2. Old Brickyard, on Chobham Road, near Golf Links
About 190 ft. above Ordnance Datum.
Water plentiful.

		Ft.
Bracklesham Beds.	Clay	9
Bagshot Beds.	White sand	29

3. Silwood Park. South Lodge, by main road.
About 5 ft. of water.

		Ft.
	Gravel	?
Bracklesham Beds.	Blue clay	17
[Bagshot Beds.]	White sand	15 or 16
	Vein of clay with pebbles	2
	White sand	5

4. Charters. In field by Gasworks.
Water abundant, 10 ft. below surface.

		Ft.
Bracklesham Beds.	Clay	4
Bagshot Beds.	Sand	14

5. Charters. On the Lawn.
About 260 ft. above Ordnance Datum.
Water plentiful, 38 ft. below surface.

		Thickness. Ft.	Depth. Ft.
Soil		2	—
Bracklesham Beds.	Green sand and clay	30	32
Bagshot Sand	White sand	7	39

6. Two other wells in farmyard and garden, both 30 ft. deep.
Water plentiful.

The records of all these wells in Sunningdale were communicated by Mr. G. Bowyer, of South Ascot.

7. Lynwood; by Gardener's cottage.
Well lined with bricks. Water-level 3 ft. from bottom.

		Thickness. Ft.	Depth. Ft.
Soil		3	3
[Bracklesham Beds.]	Gravel and pan	2 to 4	6
	Green clay with lignite	30	36
[Bagshot Beds]	White sand	10	46
	Dark brown clay	22	68

Sunning Hill.

1. The Ascot District Gas Co.
210 ft. above Ordnance Datum.
Made and communicated by Messrs. C. Isler & Co.

Tubes: 90 ft. of 8½-in. diameter; 480 ft. of 5-in. diameter.

Supply: 3,000 gallons an hour.

[Site engraved on map.]

		Thickness. Ft.	Depth. Ft.
	Made ground	1	1
[Bagshot Sand]	Brown loam	20	
	Light sandstone	21	
	Dark loamy sand	10	
	Boiling sand	36	
	Dark sand and pebbles	7	
	Boiling sand	20	115
[London Clay] 360 ft.	Loamy sandy clay (? Claygate Beds)	30	145
	Blue clay	330	475
[Reading Beds]	Mottled clay	9	484
	Red marl	8	492
	Green loamy sand	3	495
	Blowing sand	touched.	—

2. Armitage Hill ... ... W.S.B., p. 81.

Bracklesham Beds 39 ft. Water in sand at base.

Made by Messrs. Tilley & Sons, 1867.

Waltham St. Lawrence.

1. Honeys, on west side of Park.

1. Honeys, on west side of Park, about 1½ miles SSW. of church.
About 130 ft. above Ordnance Datum.

Well sunk in 1910; supply ample; information obtained on the spot.

		Thickness. Ft.	Depth. Ft.
[Plateau Gravel]	Gravel	2	2
[London Clay]	Clay	16	18
	Green sand with shells and pebbles; Basement Bed	touched.	

2. Brewery House, Castle Street [In **Shurlock Row**] W.S.B., p. 88.

Soil and drift gravel 16 ft.; London Clay (basement beds) 10 ft.; Reading Beds 61 ft.; in Chalk 17 ft.; total 104 ft

Water 20 ft. down. Boring by Mr. A. Callas, 1894.

Warfield *see* Bracknell.

White Waltham.

Waltham Place ... ... W.S.B., p. 91.

Reading Beds 61 ft.; in Chalk 7 ft. No information as to water.

Windsor.

1. Burge & Co.'s Brewery ... ... W.S.B., p. 92.
River deposits 14 ft.; London Clay 5½; Reading Beds 69½; in Chalk ? 211 ft.; total 300 ft.
Water 20 ft. down; supply plentiful.
Bored by Messrs. C. Isler & Co., 1888.

2. The Castle ... ... W.S.B., p. 92.

3. Clewer Lodge, Spittal ... ... W.S.B., p. 93.
London Clay 88 ft.; Reading Beds 87 ft.; in Chalk 40 ft.
Sunk 40 ft., rest bored. No information about water.

4. Mr. Ramsbottom's ... ... W.S.B., p. 93.

5. Royal Brewery, Peascod Street... ... ... W.S.B., p. 93.
Reading Beds 72 ft.; Chalk below.

6. R. White & Sons, St. Leonard's Road ... W.S.B., p. 93.
River Deposits about 20 ft.; London Clay 98; Reading Beds 77; Chalk and flints 162⅔ ft.; total 357⅔.
Water 9 ft. down, lowered to 18½ by pumping; yield 1,000 gallons an hour.
Boring by Messrs. C. Isler & Co.

7. Brewery (late Jenning's), Thames Street ... W.S.B., p. 94.

8. The Conservatory Cottage, near Cumberland Lodge [3½ miles south of Windsor Castle] ... W.S.B., p. 94.
Bagshot Sand with ? some Claygate Beds 56 ft.; London Clay 314; Reading Clay (sand below) 26 ft. Water rose 240 ft. Well closed.

9. Windsor Water Works [In Bucks] ... ... W.S.B., p. 94.

10. Royal Albert Laundry.
Mrs Barrow, 73, Bourne Avenue, Spittal.
80 ft. above Ordnance Datum.
Made and communicated by C. Isler & Co., 1911.
Tubed, 240 ft.; diameter, 5 ins.; supply, 1,000 gallons an hour.
Rest-level of water, 6 ft. below surface.

		Thickness.		Depth.	
		Ft.	In.	Ft.	In.
	Dug well	4	0	4	0
[London Clay]	Yellow clay	19	6	23	6
	Clay stone	1	6		
	Blue clay	90	0		
	Sandy clay and pebbles. [Basement Bed]	3	6	118	6
[Reading Beds] 81½ ft.	Mottled clay	12	0		
	Yellow clay	19	6		
	Blue sandy clay	4	0		
	Running sand	11	0		
	Hard mottled clay	4	0		
	Red mottled clay	29	9		
	Green-coated flints	1	3	200	0
Uppor Chalk	Chalk and flints	150	0	350	0

Total hardness 10·9. Permanent hardness 0·7.

11. Reid's Brewery, Thames Street.
About 71 ft. above Ordnance Datum.
Supply ample.

	Ft.
River ballast	20
Chalk	233

12. Castle Water Works. On the river bank near the Lock.

	Ft.	Ft.
Alluvium	10	10
Gravel	28	38
Chalk	9	47
(Water from the gravel ?)		

Winkfield.

1. The Plain	W.S.B., p. 95.
2. The Row	W.S.B., p. 95.

3. New Lodge, Windsor Forest.

The site is engraved on the map and is over 3½ miles WSW of Windsor Castle (Lat. 51.28, Long. 0.41.10 W).

218 ft. above Ordnance Datum.

Made and communicated by Messrs. Le Grand & Sutcliff, 1893.
Shaft, 8 ft., the rest bored.

		Thickness. Ft.	Depth. Ft.
[London Clay]	Brown and blue clay with [septaria]...	115	115
	Brown, dead sand, green sand and shells (Basement bed)	21	136
[Reading Beds] 78 ft.	Mottled clay and sand	56	
	Light coloured blowing sand... ...	22	214
[Upper Chalk] 337 ft.	White chalk and flints	329	
	Hard grey chalk and flints ? Chalk rock	8	551
[Middle Chalk] 169 ft.	Hard white chalk, flint bands near top	147	
	Chalk marl	4	
	Hard white chalk	4	
	Very hard white chalk [? Melbourn Rock]	14	720
[Lower Chalk] 219 ft.	White and green chalk [? Belemnitella) marl)	6	
	White chalk and hard grey chalk ...	122¾	
	Hard dark-grey chalk [? Totternhoe Stone]	18¼	
	Blue and dark brown clayey chalk ...	22	
	Chalk marl	50	939
[Upper Greensand.]	Hard grey marl, calcareous malmstone and grey sandstone	31	970
Gault ...	Dark grey clay and light grey clay ...	264	1,234
Lower Greensand	Light brown sand	9	1,243

A detailed account of this boring is published in W.S.B., pp. 95-96.

The water overflowed at the surface when the boring was made and still does so in 1914.

BUCKINGHAMSHIRE.

Datchet.

For the Slough Waterworks Company. 1882?
[Site, 5 furlongs north-west of Datchet Church. O.D. 63. Engraved on map.]
J. Lobley, *Proc. Geol. Assoc.*, vol. vii., No. 7, pp. 391-395.
Boring, 3 ft. diameter. Water overflowed.

		Thickness. Ft.	Depth. Ft.
Soil	... ...	1	1
[Valley Drift]	Brick-earth, the lower 3½ ft. more sandy	6½	—
	Gravel and sand	11½	19
[London Clay] 20 feet.	Blue sandy and mottled clay... ...	20	39
[Reading Beds] 78 feet.	Red, brown, blue and yellow mottled clay and brown sand	77	—
	Flints	1	117

Chalk touched.

A detailed account is published in L.M., p. 334.

Ditton Park.

Between Slough and Colnbrook ... ... L.M., p. 8.

Dorney.

2 trial-borings on the Common ... ... L.M., pp. 8, 9.

Langley.

1. Langley Cottages, east of Slough, for the Great Western Railway Co.
85 ft. above Ordnance Datum.
Bored well, diameter 4 ins. Water-level 3 ft. below surface.

	Thickness. Ft.	Depth. Ft.
Soil and Mould...	1	1
Clay [Brick-earth]	4	5
Ballast	10	15
London Clay	45	60

2. Langley House [O.D. 80] ... ... L.M., p. 9.
To Chalk 124 ft.

Slough.

1. Horlick's Malted Milk Factory; just north of railway at western junction of main line and Windsor Branch.
[Site engraved on map.]
100 ft. above Ordnance Datum.
Made and communicated by Messrs. C. Isler & Co., 1909.
Lined with tubes 8½-in. diameter to 782 ft.; top 90 ft. also 18-in. diameter tubes; top 20 ft., tubes 20-in. diameter.

Water overflowed at surface at 100,000 gallons per hour.

		Thickness.		Depth.	
		Ft.	In.	Ft.	In.
	Top soil...	6	6	6	6
[River Deposits]	Sands and gravel	18	0	24	6
[Reading Beds] 54 feet.	Running sand ...	20	0		
	Brown mottled clay	0	6		
	Running sand ...	12	0		
	Blue clay	7	0		
	Red mottled clay	8	0		
	Yellow mottled clay	2	0		
	Yellow clay and flints	4	6	78	6
[Chalk] 757½ ft.	Chalk and flints	463	3	541	9
	Hard chalk	154	9	696	6
	Grey chalk	96	0	792	6
	Green sandy chalk	6	0	798	6
	Grey chalk	37	6	836	0
[Upper Greensand]	Grey sandy chalk [with Glauconite] ...	19	4	855	4
Gault	Hard blue clay	166	2	1,021	6
[Lower Greensand].	Lower Greensand	13	0	1,034	6

2. Eton Union ... ... L.M., p. 9.
To Chalk 131 ft.

3. Railway Station... ... ... L.M., p. 10.

4. Royal Nursery ... ... L.M., p. 10.
River Deposits 27 ft.; London Clay 31; Reading Beds 36; in Chalk 17½. No information as to water.

5. Upton Park ... ... L.M., p. 10.

6. Waterworks ... ... L.M., p. 10.
River Deposits 29 ft.; London Clay 20½; Reading Beds 41½; Chalk 495 ft.; total 586.

Shaft 117 ft., with a heading in the Chalk; rest 25-in. bore.

Water rose 7 ft. above ground in 1869 Yield ? 40,000 gallons an hour.

Wyrardisbury (Wraysbury).

1. At back of stables at Ankerwyke; near the Thames.
55 ft. above Ordnance Datum.

Made by Messrs. C. Isler & Co. in 1906 for Mr. A. H. Benson, and communicated by him.

Lined with 5-in. tubes to the Chalk. Supply 3,000 gallons a day. Water-level 20 ft. below surface. Pumping 1,000 to 1,500 gallons an hour does not lower the water-level. Hardness, 4°.

		Thickness. Ft.	In.	Depth. Ft.	In.
	Made ground	1	0	1	0
[Superficial deposits.]	Sand and gravel	19	0	20	0
	Thames gravel	7	0	27	0
[London Clay] 56 ft.	Blue clay	14	0		
	Claystone	0	6		
	Blue clay	42	0	83	6
[Reading Beds] 85½ ft.	Mottled clay	28	0		
	,, ,, and pebbles	8	0		
	Brown clay	19	0		
	,, sand	20	6		
	Blue clay	10	0	169	0
Upper Chalk	Chalk and flints	101	0	270	0

2. Copper Mills. L. M., p. 11.

MIDDLESEX.

Ashford.

West London District Schools.
On the south side of the L. and S.W. Railway, about 1 mile east of Staines.
About 60 ft. above Ordnance Datum.

Two wells and borings, 20 ft. apart, have been made here by Messrs. Tilley, the first in 1901, the second in 1904.

Shaft 100 ft., the rest a 12-in. bore.

Mr. T. L. Gosling, Superintendent of the Schools, has supplied the following information and section of the beds passed through in the second well and boring—'The water-level varies with the pumping; should this be stopped, the water in the well rises to the surface and at the end of 14 days overflows. During the year ending 30th June, 1914, the meter showed that approximately 7,349,700 gallons had been raised. The pumps work, on and off, from 6 a.m. to 9 p.m., when the water in the well is lowered. By resting at night the level of the water rises for next day's supply.'

This gives a yield of roughly 20,000 gallons in 15 hours. The well is interesting as being of the type formerly used in London. The sunk well acted as a reservoir, which fills up more or less during the period of rest, and so allows the water to be raised at a considerably greater rate than the borehole supplies it. The use of such a well is entirely dependent on a high water-level; in London itself this type of well is now permanently dry, or nearly so, owing to the fall of the water-level, so that boreholes alone are now used.

		Thickness. Ft.	Depth. Ft.
[River Deposits]	Gravel and shingle	18⅓	18⅓
[London Clay] 215⅔ ft.	London Clay with clay stones[1] ...	207⅔	226
	Loamy clay	8	234
[Reading Beds] 88 ft.	Mottled clay	1	235
	Red mottled clay	11	246
	Yellow mottled clay	3	249
	Yellow chalky[2] clay	10	259
	Slightly mottled sandy clay	5	264
	Sandstone	2	266
	Coloured clay	11	277
	Plastic clay	6	283

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[1] At a depth of 44-45 ft. a bed of big black flints occurred embedded in the clay.

[2] The chalk or chalky clay is almost certainly race, which is often abundant in the Reading clays.

		Thickness. Ft.	Depth. Ft.
[Reading Beds] 88 ft.	Sandstone	3	286
	Plastic clay	7	293
	Mottled clay	10	303
	Clay	8	311
	Mottled clay with chalk[1] and small pebbles	2	313
	Light green clayey sandstone...	4	317
	Greenish mottled clayey sandstone ...	2	319
	Dark green clayey sandstone ...	1	320
	Black flints	2	322
	Chalk below.		

Feltham.

Near the Station, Messrs. Pritchett & Gold, 1907.
Boring communicated by Messrs Le Grand & Sutcliff.
About 70 ft. above Ordnance Datum.
Water-level, 34 ft. above O.D. ; yield, 150 gallons an hour.

			Thickness. Ft.	Depth. Ft.
[River] Gravel			10	10
[London Clay 294½ ft.]		Brown clay	1	11
		Blue clay and septaria. A little sandy below 285 ft.	283	294
	[Basement bed]	Sandy clay	7½	301½
		A few black [flint] pebbles		
		Sandy clay	3	304½
[Reading Beds 90½ ft.]		Mottled clay	61½	
		Sand	2½	
		Mottled clay	8½	377
		Loamy sand [? Thanet]	20	397
Chalk and flints, soft			250	647
Grey chalk			53	700

Harlington.[2]

New Police Station. 1889.
About 85 ft. above Ordnance Datum.
Communicated by Mr. J. Butler, Surveyor to the Metropolitan Police.

Cylinders and shaft about 26 ft., including 5 ft. above the level of the ground (with a pipe a few feet higher), the rest bored; the bore-pipe carried up to just above the level of the ground.

A plentiful supply of water, which rose 8 ft. above the surface.
Water stood 6 ft. below surface in 1911.

	Thickness. Ft.	Depth. Ft.
Soil	1	1
[River Drift.] Clean gravel, charged with water	8½	9½
Blue [London] Clay. Claystones, with water, at 39½ to 40, 60 to 61, and 102 to 104 ...	150½	160

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[1] The chalk or chalky clay is almost certainly race, which is often abundant in the Reading clays.

[2] Whitaker, W. 'Some Middlesex Well Sections.' *Trans. Brit. Assoc. Water-works Engineers,* vol. ii, 1897.

		Thickness. Ft.	Depth. Ft.
[Reading Beds 131½ ft. ?]	Mottled clay	83	
	Loose sand and small stones [pebbles]; copious supply of water	4	
	Brown clay	9	
	Brown mottled clay	6½	
	Hard sand with water	13	
	Very hard, dark blue clay	11	
	Green sand	1½	
	Flints	2	290
Chalk	... ...	31	321

The thickness assigned above to the Reading Beds is far in excess of any other record in the London Basin. Perhaps the 83 ft. of mottled clay belongs to the London Clay, the underlying sand and pebbles being the basement-bed; but in this case the Reading Beds are much thinner than in the neighbouring wells (excepting some at Uxbridge). ' [? a mistake in the figures.]

Hatton.

[Misprinted *Halton.*] Sir F. Pollock's ... ... L.M., p. 106.

Littleton House.

Nearly 2 miles NE of Chertsey ... ... L.M., p. 130.
About 40 ft. above Ordnance Datum.

Two wells were made here; the first in 1835, stopped in the Reading Sands at a depth of 520 ft. The second, made by Messrs. Tilley & Sons in 1871 reached the Chalk at a depth of 570 ft. and was carried 130 ft. into the Chalk.

The great depth to the Chalk suggests there might be some Bagshot Sands here lying in a syncline; though it is probable that most of the sandy beds above the typical London Clay belong to the passage or Claygate Beds.

When first made, the water from the Reading Sands rose to a height of 16 ft. above ground, at a rate of one gallon a minute. When this source failed and the new well was made, the water from the Chalk rose 3 ft. above ground, but only at the rate of one pint a minute. This well is referred to on p. 17.

Staines.

1. Messrs. Ashby & Co.'s Brewery. Second well.
55 ft. above Ordnance Datum.
Made and communicated by Messrs. C. Isler & Co.
Cylinders of 6 ft. diameter for 30 ft., and of 5 ft. diameter for 120 ft.: 235 ft. of tubes of 11½ in. diameter, from 125 ft. down.
An abundant supply from the sand beds.
[Site engraved on map.]

		Thickness. Ft.	Depth. Ft.
River Gravel	... ...	23	23
[London Clay] 283⅓ ft.	Blue clay with claystones	279⅓	
	Brown clay	4	306⅓
[Reading Beds] 74⅙ ft.	Mottled brown and sandy clay ...	74⅙	
Flints and chalk	... ...	1⅙	381⅔

For further details of this well see W. Whitaker, 'Some Middlesex Well Sections,' *Trans. Brit. Assoc. Water. Engineers,* vol. ii, 1897, and for account of another well at the Brewery see L.M., p. 161.

2. Middlesex and Surrey Laundries, London Road.
Made and communicated by Messrs. C. Isler & Co.
50 ft. above Ordnance Datum. Water-level 100 ft. down.
Supply 1,000 gallons an hour. Lined with 370 ft. of 5-in. tubes, from surface and 60 ft. of 4-in. perforated tubes, 365 ft. from surface.

		Thickness. Ft.	Depth. Ft.
	Made earth	1	1
[River Deposits] 19 ft.	Loamy clay [Brickearth]	4	5
	Ballast	15	20
[London Clay] 320 ft.	Brown and blue clay with claystones	293	
	Blue sandy clay	5	
	Green sandy clay	8	
	Brown sandy clay	14	340
[Reading Beds] 78 ft.	Mottled clay	18	
	Yellow clay and stone	12	
	Dark red clay	3	
	Brown loamy sand (with water) ...	7	
	Red clay and stone	11	
	Brown clay	3	
	Hard sand-rock	3	
	Blue clay	1	
	Brown clay	7	
	Black clay	2	
	Dark green clay	4	
	Dark grey clay	1	
	Green clay and pebbles	7	
	Dead green sand	3	422
	Chalk	4	426

Stanwell.

Poyle Mills, near Colnbrook ... ... L.M., p. 161.
River Deposits 18 ft.; Lower Tertiary 189 ft.; in Chalk 175 ft.
Most of the water came from the Reading Sands, at 203 ft. down.

West Drayton.

1, Smith's Mills ... ... L.M., p. 176.
River Deposits 16 ft.; London Clay 63; Reading Beds 70; Chalk below.

2. Victoria Oil Mills ... ... L.M., p. 176.
River Deposits 29 ft.; London Clay 88; Reading Beds 66; in Chalk 100.
Shaft 12 ft., rest bored. Water overflowed in 1872.
Made by Messrs. Docwra.

3. Vitriol Works ... ... L.M., p. 176.
River Deposits 15 ft.; London Clay 60; Reading Beds 58½; in Chalk 45½.

4. Varnish Works ... ... L.M., p. 177.
To Chalk about 200 ft.; in Chalk 60 ft.

5. Britannia Brewery ... ... P.G.S., p. 167.
River Deposits 12½ ft.; London Clay 95; Reading Beds 73½; in Chalk 76½.

6. Rotary Photographic Co.
90 ft. above Ordnance Datum.

Made and communicated by Messrs. C. Isler & Co. 1901.
Lined with 180 ft. of tubes, 13½ in. in diameter.

Water rose 14 ft. above ground when made. Water-level in 1914; at rest, from 75 to 70 ft. above O.D.; pumping from 60 to 10 ft., according to the quantity required. Yield from 3,000 to 12,000 gallons an hour. Information from the manager.

[Site engraved on map.]

		Thickness. Ft.	Depth. Ft.
[River Drift].	Blue clay [? alluvial]	2	2
	Ballast [gravel]	4	6
	,, ,, and clay	4	10
Blue [London] clay		83	93
[Reading Beds 76 ft.]	Mottled clay	30	
	Sandy clay and pebbles	10	
	Brown sand	6	
	Sandy clay	3	
	Live sand	10	
	Blue clay and stones	7	
	Blue and black clay	7	
	Green sand and flints	3	169
	Chalk and flints	131	300

7. For Great Western Railway Company. By R. Colne, where branch line to Staines passes under main line.
88·13 ft. above Ordnance Datum.

		Thickness. Ft.	 In.	Depth. Ft.	 In.
	Soil	3	0	3	0
[River deposits]	Gravel	16	0	19	0
[London Clay]	Hard clay	69	0		
	Rock	0	2		
	Sandy clay	22	0		
	Gravel [Basement Bed] (water found 111 ft. down)	1	0	111	2
[Reading Beds] 77 ft.	Sand	4	0		
	Clay	15	0		
	Red Clay (2 in. of Rock ⅓ way) ...	16	0		
	Sand	2	0		
	Clay	8	0		
	Sand	16	0		
	Stiffer black clay	11	0		
	Clay and rock	4	0		
	Hard stone	1	0	188	2
[Chalk] ...	Rock and chalk	1	4	189	6
	Chalk	24	8	214	2
	Chalk, sand and flints	10	0	224	2
	Sandy chalk	3	0	227	2
	Chalk	11	0	238	2

8. Rickmansworth and Uxbridge Valley Water Co.
North side of Canal, in angle by branch to wharf. 1911.
Information supplied by the company.
106 ft. above Ordnance Datum.
Water-level 76 ft. above O.D.; supply 25,000 gallons an hour.

		Thickness. Ft.	Depth. Ft.
[River Deposits] 10 ft.	Soil	1	1
	Gravel	9	10
[London Clay] 106½ ft.	Blue clay	15	
	Clay and stones	½	
	Blue clay	39½	
	Clay and stones	½	
	Blue clay	5½	
	Clay and stones	½	
	Blue clay	40½	
	Mottled clay	3	
	Sand, shells and pebbles	1½	116½
[Reading Beds] 64½ ft.	Mottled clay	13½	
	Hard yellow clay	15	
	Soft dark sand...	21	
	Light clay stones	¾	
	Soft dark sand...	5¼	
	Blue clay	8	
	Flints	1	181
[Upper Chalk] 119 +	Chalk and flints	77	258
	Hard chalk	42	300

SURREY.

Bagshot.

Albert Orphan Asylum. 1866 (?)
400 ft. above Ordnance Datum.
Communicated by Messrs. Easton & Amos.
Sunk 123 ft., the rest bored.
[Site engraved on map.]

		Thickness. Ft.	Depth. Ft.
	Gravel	9	9
Barton Beds	Light green sand	—	
	Yellow sandy loam and stones	228½	237½
Bracklesham Beds	Dark sand with seam of pebbles	21½	
	Green sand and clay	49	
	Sandy clay	18	326
Bagshot Beds	Light coloured sand, brown sand, sand rock and sandy clay*	128	454
London Clay	Blue clay	192	646

* [This may belong in part to the London Clay.]

For full details see W.S.S., p. 106.

The 445 ft. (?) of Bagshot Beds given in Mr. Whitaker's account are here subdivided in accordance with the classification adopted in this Memoir.

Chertsey.

1. Brewery. 1872 ... ... W.S.S., p. 133.

2. Brewery, 2nd well. W.S.S., p. 133.
45 ft. above Ordnance Datum.
Bored and communicated by Messrs. C. Isler & Co., 1888.
Water overflowed at the rate of 430 gallons an hour.
[Site engraved on map.]

		Thickness. Ft.	Depth. Ft.
	Made ground	5	5
[River Gravel]	Ballast	28	33
[Bagshot.]	Sand	17½	50½
[London Clay] 361½ ft.	Sand and blue clay [? Passage beds]	23½	74
	Blue clay; with claystone at 155–156, claystone and pebbles at 179–180, claystone and pyrites at 195–197 and 240–242, and claystone at 384–385	338	412
[Reading Beds] 104 ft.	Green sand	15	
	Mottled clay	30	
	Brown loamy sand	18	
	Sand and water	15	
	Brown clay	15	
	Green sand	11	516
[Upper Chalk]	Chalk	304	820

According to Mr. E. A. Martin the boring has been continued 180 ft. deeper in the Chalk, giving a total depth of 1,000 ft. *Science Gossip*, 1908, new ser., vol. v, p. 119.

3. Sandgate ... ... W.S.S., p. 133.

4. Ottershaw Park.
About 3 miles SE. of the centre of the town.
142·5 ft. above Ordnance Datum.

Boring made by Messrs. Duke & Ockenden. Information from them and from specimens in the Survey Office. Additional notes by Mr. W. H. Booth.

Water overflows, 78 ft. above surface at the rate of 5,500 gallons per hour. The overflow at the surface was 132,000 gallons a day.

Lined with tubes decreasing from 12-in. diameter to 3-in., below 1,530.

[Site engraved on map.]

Accounts of this boring have already been published[1] on the authority of Mr. Reid, from information supplied to, and specimens seen by, him. A large number of additional specimens from the Cretaceous Beds have, however, been obtained, and are now in the Survey Office. From the two sets of specimens an amended account of the boring, below the point where the Chalk was reached, has been drawn up, and is given below. In the upper part of the boring the percussion method of boring was used; this tool tends to drive material in front of it, and for this reason it is possible that the divisions between certain of the Tertiary Beds has been taken too low. (See p. 49.)

Owing to gaps in the series of specimens, the respective thicknesses of the Upper, Middle and Lower Chalk, are not known. The Lower Chalk cannot be less than 178 or more than 245 ft. thick. Comparison with the Winkfield boring given above, suggests the lower figure as more probable, leaving about 460 ft. for the Upper and Middle Chalk taken together.

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[1] 'Summary of Progress for 1910.' *Mem. Geol. Surv.*, 1911, pp. 25, 26. 'Water Supply of Surrey.' *Mem. Geol. Surv.*, 1912, p. 134.

The Lower Greensand here, as elsewhere, proved quite loose and decomposed. In consequence a great quantity of fine sand was brought up by the overflowing water. It was largely shut out by driving a perforated pointed pipe into the soft rock.

			Thickness. Ft.	Depth. Ft.
[Bracklesham Beds] ? 89 ft.		No record	63	63
		Loamy greenish sand	7	70
		Blacker loamy clay	19	89
[Bagshot Sand] ? 124 ft.		Loamy green sand with large flakes of mica	31	
		Blacker loamy sand	5	
		Fine greenish sand	22	
		Coarser green sand	14	
		Loamy greenish sand	17	
		Dark loamy sand	35	213
[London clay] 336 ft.		Dark clayey sand	26	
		Micaceous loam	21	
		Shelly brown clay	20	
		Brown clay	21	
		Clay with bed of pebbles	4	
		Dark loamy sand	3	
		Clay and pebbles	4	
		Brown clay with septaria	60	
		Dark brown clay	149	
		Micaceous sandy clay	27	
		Brown clay with stone and fossils [Basement bed]	1	549
[Reading Beds] 100 ft.		Mottled white and red clay	71	
		Light brown sand	5	
		Black clay	7	
		Black and red clay	8	
		Green loamy sand	8	
		Green-coated flints	1	649
[Upper and Middle Chalk] 401 or 468 ft.	[Upper Chalk]	Soft white chalk, black flints with thin rind	40	689
		No specimens: a mixture of chalk and tertiary material brought up from borehole	211	900
	[Middle Chalk.]	Hard white chalk, with *Terebratula* and *Rhynchonella*	27	927
		Cream-coloured chalk, very hard and splintery	9	936
		Yellow and grey marly chalk	10	946
		Hard white chalk with *Inoceramus*, etc.	104	1,050
		No specimens	67	1,117
[Lower Chalk] 245 or 178 ft.	[Lower Chalk.]	Buff chalk with greenish tinge	6	1,123
		White chalk	30	1,153
		Greyish chalk	107	1,260
		Dark grey marly chalk	35	1,295
[Upper Greensand] 40 ft.		Dark brownish grey marl, highly glauconitic. [Marls]	25	1,320
		Hard light grey sandy micaceous marl with *Pecten orbicularis* (passing into next). [Hearthstones.]	15	1,335
[Gault] 238 ft.		Sandy micaceous marls with nodules	30	1,365
		Marl with nodules and patches of glauconite	4	1,369
		Grey marl (glauconite at 1,380)	204	1,573
[Lower Greensand.]		Coarse quartz sand, fairly-well rounded	12	1,585

NOTE.—At 1,184 ft. a specimen of *Ammonites mantelli* was found; at 1,290 ft., of *A. naviculare*.

5. Foxhills.

On the Foxhills estate, south-west of Chertsey, several wells have been sunk. At France Farm a well, made in 1911 about 50 yds. south-west of the farm buildings, was 70 ft. in depth, passing through Bagshot Sands with pipe-clay and ironstone. Water was fairly plentiful, but too brackish for domestic use. Another at the north-west corner of the farm buildings was sunk to a depth of 45 ft. At 25 ft. below the surface a bed of pipe-clay 1 in. thick was encountered in the sands. This bed held up some water; a further supply was met with at 45 ft., but the water showed strong organic contamination, apparently from the adjoining farmyard. The site of both these wells is at 140 ft. O.D.

About 300 yds. north-west of Foxhills House a well was made close to the course of a small stream; it was sunk 40 ft. and then bored a further 20 ft. The section showed 22 ft. of Bracklesham Beds separated by an iron pan from the underlying Bagshot Sands. A very copious supply was obtained, but the water was too ferruginous to be of use. The site was selected by a diviner, who stated that two springs intersected at the point.

The supply for France Farm House is obtained from a natural spring 800 yards to the south-west. The water is derived from the upper sandy part of the Bracklesham Beds, being thrown out by the lilac clays. The spring feeds a settling tank, whence the water is pumped. The supply is measured periodically, and averages 900 gallons per day with little variation. Quality of water excellent.

Chobham Place.

W.S.S., p. 135.

Upper Bagshot [? Barton] about 100 ft.; Middle Bagshot [? Bracklesham] 40 ft.; Lower Bagshot [Bagshot Sands] 100 or ? more; London Clay 400; Reading Beds 50; in Upper Chalk 150. Water rose to 100 ft. below surface.

Egham.

1. Callow Hill	W.S.S., p. 156.
2. Mr. Mills'	W.S.S., p. 156.
3. Staines, South-West Suburban Waterworks ...	W.S.S., p. 156

River Deposits 23 ft.; London Clay 235; Reading Beds 96; in Chalk about 346; Chalk rock at bottom of bore (700 ft.).

Shaft 360 ft.; the rest bored. When the water-level was reduced by pumping to 130 ft. below the surface, the sands in the Reading Beds yielded 24,000 gallons an hour (April, 1883). With water-level at 97 ft., the Chalk yielded 420 gallons an hour (October, 1882). This well shows clearly how much more rapidly water passes through sand than through Chalk, unless the latter be fissured. Made in 1883 by Messrs. T. Tilley.

Longcross.

Fairfield, near Chobham Common.
About 180 ft. above Ordnance Datum.
Bored and communicated by Messrs. Callas, Sons & May. 1913.

		Thickness. Ft.	Depth. Ft.
	Top soil...	2	2
[Bracklesham Beds.]	Dark green sand, loam, and water ...	1	
	Pebble bed	½	
	Dark green sandy loam	12½	
	Very hard grey sand	14	
	Motley sand	4	
	Brown sandy loam and clay	4	
	Motley loam	2	40
	Lead-colour sandy loam, with water	43	83
	Blue clay	2	85

Thorpe.

Holloway Sanatorium ... W.S.S., pp. 242, 243.
Less than a quarter of a mile NNE. of Virginia Water Station.
120 ft. above Ordnance Datum.

[Lower Bagshot and passage-beds into London Clay ?] 110 ft.; London Clay 329; Reading Beds 86; Upper Chalk 275; total 800 ft.

Shaft 115 ft.; the rest bored. Water-level (from the Chalk) about 40 ft. down; but the yield at 360 ft. not more than 2 gallons a minute.

Made and communicated by Messrs. TILLEY, 1884.

Windlesham.

1. The Village Wells ... ... W.S.S., p. 256.

2. Highams (or Hyams).
210 ft. above Ordnance Datum.
Boring from bottom of old well, made and communicated by Messrs. MERRYWEATHER.
Abandoned, not sufficient water.
[Site engraved on map.]

		Thickness. Ft.	Depth. Ft.
[Bracklesham Beds.] 86 ft.	Old well—strata not known	39	39
	Green loam and sand	20	59
	Light coloured and mottled clay ...	27	86
[Bagshot Beds] 106 ft.	Green and grey sand with sandstone...	73	159
	Green sand and pebbles	7	166
	Dark sand and loam	28	194

For details see W.S.S., pp. 256, 257.

Addendum.

MIDDLESEX.

Yiewsley.

For Mr. TREVOR WILLIAMS. Boring about 600 yards east of West Drayton Station, on south side of G. W. Railway.

Made and communicated by Messrs. LE GRAND & SUTCLIFF, 1904.

Water rose 4 inches above surface; yield 1,200 gallons an hour.

Soil and gravel 18 ft.; London Clay ? 93 ft.; Reading Beds 72 ft.; in Chalk 47 ft.; total 230 ft.

APPENDIX II.

LIST OF PRINCIPAL WORKS ON THE GEOLOGY OF THE DISTRICT.

1819. SMITH, W. Geological Map of Berkshire.

1824. WARBURTON, H. On the Bagshot Sand. *Trans. Geol. Soc.*, ser. 2, vol. i, pp. 48-52.

1847. PRESTWICH, J. On the main points of Structure and the probable Age of the Bagshot Sands. *Quart. Journ. Geol. Soc.*, vol. iii, pp. 353–409.

1850-1854. PRESTWICH, J., Junr. On the Structure of the Strata between the London Clay and the Chalk in the London and Hampshire Tertiary Systems. *Quart. Journ. Geol. Soc.*, vol. vi, pp 252-281; vol. viii, pp. 235–264; and vol. x, pp. 75–170.

1857. PRESTWICH, J. On the correlation of the Eocene Tertiaries of England, France and Belgium. *Quart. Journ. Geol. Soc.*, vol. xiii, pp. 89–134.

1872. WHITAKER, W. Geology of the London Basin. *Mem. Geol. Surv.*, vol. iv, part I.

1879. GARDNER, J. S. On the correlation of the Bournemouth Beds . . . with the Upper and Middle Bagshot Beds of the London Basin. *Geol. Mag.*, pp. 148–154.

——. On the British Eocenes and their Deposition. *Proc. Geol. Assoc.*, vol. vi, pp. 83–106.

1881. HERRIES. W. H. On the Bagshot Beds. *Geol. Mag.*, pp. 171-174.

JONES, T. R. On the Geology and Physical features of the Bagshot District. *Proc. Geol. Assoc.*, vol. vi., p. 429.

1883. IRVING, Rev. A. On the Bagshot Sands as a source of Water supply. *Geol. Mag.*, pp. 404–413.

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1885. IRVING, Rev. A. General Section of the Bagshot Strata from Aldershot to Wokingham. *Quart. Journ. Geol. Soc.*, vol. xli, pp. 492-510.

——. Excursion to Aldershot and Wellington College. *Proc. Geol. Assoc.*, vol. ix, pp. 219–222.

——. Excursion to Wokingham, Easthampstead and Ascot. *Proc. Geol. Assoc.*, vol. ix, pp. 222–224.

——. Water Supply from the Bagshot and other Strata. *Geol. Mag.*, pp. 17–25.

1886. HUDLESTON, W. H. On a recent section through Walton Common. *Quart. Journ. Geol. Soc.*, vol. xlii, pp. 147–172.

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MONCKTON, H. W., and R. S. HERRIES. The Bagshot Beds of the London Basin. *Quart. Journ. Geol. Soc.*, vol. xlii, pp. 402–417.

1887. HUDLESTON, W. H. Supplementary Note on the Walton Common Section. *Quart. Journ. Geol. Soc.*, vol. xliii, pp. 443–456.

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1888. GARDNER, J. S., KEEPING, H., and H. W. MONCKTON. The Upper Eocene comprising the Barton and Upper Bagshot Formations. *Quart. Journ. Geol. Soc.*, vol. xliv, pp. 578–635.

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1889. Lyons, H. G. Notes on the Bagshot Beds and their Stratigraphy. *Quart. Journ. Geol. Soc.*, vol. xlv, pp. 633-639.

Monckton, H. W., and R. S. Herries. On some Bagshot Pebble Beds and Pebble Gravel. *Proc. Geol. Assoc.*, vol. xi, pp. 13–23.

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1893. Hudleston, W. H. Anniversary Address of the President. *Quart. Journ. Geol. Soc.* (*Proc.*), vol. xlix, pp. 46–142.

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1896. Treacher, Ll. Palaeolithic Man in East Berks. *Berks, Bucks, and Oxon Arch. Journ.*, vol. ii, 1896, pp. 16–18.

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Photographs.

In addition to the photographs reproduced in the Memoir, there are a few others in the Survey Collection which illustrate the physiography and structure of this area, and of which Lantern slides or Prints may be obtained.

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